QK1
.L5642
1904-13
v. 7

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY

OF

LONDON.

SECOND SERIES.—VOLUME VII.

BOTANY.

LONDON:

PRINTED BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET:

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE;

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

1904–1913.

CONTENTS.

PART I.—December, 1904.

I. *An Account of the Jamaican Species of* Lepanthes. *By* William Fawcett, *B.Sc., F.L.S., and* A. B. Rendle, *M.A., D.Sc., F.L.S.* (Plates 1 & 2.) page 1

PART II.—March, 1905.

II. *The Morphology and Anatomy of the Stem of the Genus* Lycopodium. *By* Charles Edward Jones, *B.Sc., F.L.S.* (Plates 3–5.) 15

PART III.—April, 1906.

III. *Contributions to the Embryology of the* Amentiferæ.—Part II. Carpinus Betulus. *By* Margaret Benson, *D.Sc., F.L.S., Senior Lecturer in Botany at the Royal Holloway College, Egham;* Elizabeth Sanday, *B.Sc.;* *and* Emily Berridge, *B.Sc., F.L.S.* (Plate 6.) 37

PART IV.—September, 1906.

IV. *On* Sutcliffia insignis, *a new Type of Medulloseæ from the Lower Coal-Measures. By* D. H. Scott, *M.A., Ph.D., F.R.S., Sec.L.S., Hon. Keeper of the Jodrell Laboratory, Royal Botanic Gardens, Kew.* (Plates 7–10.) 45

PART V.—March, 1907.

V. *Remarks on the Structure of Bamboo Leaves. By* Sir Dietrich Brandis, *K.C.I.E., Ph.D., F.R.S., F.L.S.* (Plates 11–14.) 69

PART VI.—October, 1907.

VI. *The* Lithothamnia *of the Percy Sladen Trust Expedition, in H.M.S. 'Sealark.' By* M. Foslie. (*Communicated by* Mr. J. Stanley Gardiner, *M.A., F.L.S.*) (Plates 15 & 16.) 93

PART VII.—NOVEMBER, 1907.

VII. *On Triassic Species of the Genera* Zamites *and* Pterophyllum: *Types of Fronds belonging to the Cycadophyta. By* E. A. NEWELL ARBER, *M.A., F.L.S., F.G.S., Trinity College, Cambridge; University Demonstrator in Palæobotany.* (Plates 17–19.) . . . . page 109

PART VIII.—JANUARY, 1908.

VIII. *The Anatomy of the* Julianiaceæ *considered from the Systematic Point of View. By* F. E. FRITSCH, *D.Sc., Ph.D., F.L.S., Assistant Professor of Botany, University of London, University College.* (Plates 20 & 21 and two Text-figures.) 129

PART IX.—JANUARY, 1908.

IX. *On the Origin of Di-trimerous Whorls among the Flowers of Dicotyledons. By the* Rev. Prof. G. HENSLOW, *M.A., F.L.S., F.G.S.* (2 Text-figures.) . . 153

PART X.—DECEMBER, 1908.

X. *Marine Algæ* (Chlorophyceæ *and* Phæophyceæ) *and Marine Phanerogams of the 'Sealark' Expedition, collected by J. Stanley Gardiner, M.A., F.R.S., F.L.S. By* A. GEPP, *M.A., F.L.S., and* Mrs. E. S. GEPP. (Plates 22–24.) 163

PART XI.—FEBRUARY, 1909.

XI. *The Anatomy of some Sapotaceous Seedlings. By* WINIFRED SMITH, *B.Sc., F.L.S.* (Plates 25 & 26.) 189

PART XII.—JULY, 1909.

XII. *A Revision of the Genus* Nototriche, *Turcz. By* ARTHUR W. HILL, *M.A., F.L.S.* (Plates 27–30.) 201

PART XIII.—SEPTEMBER, 1909.

XIII. *The Longitudinal Symmetry of the* Centrospermæ. *By* PERCY GROOM, *M.A., D.Sc., F.L.S., Assistant Professor of Botany, Imperial College of Science and Technology, London.* (26 Text-figures.) 267

PART XIV.—NOVEMBER, 1909.

XIV. *The Structure and Affinities of* Davidia involucrata, *Baill. By* A. S. HORNE, *B.Sc., F.G.S., Marshall Scholar at the Royal College of Science, London.* (*Communicated by* Prof. J. BRETLAND FARMER, *F.R.S., F.L.S.*) (Plates 31–33.) 303

PART XV.—OCTOBER, 1910.

XV. *The Anatomy of* Welwitschia mirabilis, *Hook. f., in the Seedling and Adult States. Forming Report No. 2 of the Percy Sladen Memorial Expedition to South-West Africa*, 1908–1909. *By* M. G. SYKES, *Girton College, Fellow of Newnham College, Cambridge.* (*Communicated by* Prof. H. H. W. PEARSON, *Sc.D., F.L.S.*) (Plates 34 & 35 and 5 Text-figures.) . . . . . page 327

PART XVI.—FEBRUARY, 1912.

XVI. *Anatomy of* Enhalus acoroides (*Linn. f.*), Steud. *By* HILDA M. CUNNINGTON, *B.Sc.* (*Communicated by* Prof. PERCY GROOM, *D.Sc., F.L.S.*) (Plate 36 and 13 Text-figures.) 355

PART XVII.—JULY, 1912.

XVII. *On* Botrychioxylon paradoxum, *sp. nov., a Palæozoic Fern with Secondary Wood. By* D. H. SCOTT, *F.R.S., F.L.S.* (Plates 37–41.) 373

PART XVIII.—JULY, 1912.

XVIII. *On* Psygmophyllum majus, *sp. nov., from the Lower Carboniferous Rocks of Newfoundland, together with a Revision of the Genus and Remarks on its Affinities. By* E. A. NEWELL ARBER, *M.A., Sc.D., F.L.S., F.G.S., Trinity College, Cambridge; University Demonstrator in Palæobotany.* (Plates 42–44 and 1 Text-figure.) 391

PART XIX.—NOVEMBER, 1912.

XIX. *On the Ferns of the Seychelles and the Aldabra Group. By* CARL CHRISTENSEN, *M.Sc.* (*Copenhagen*). (*Communicated by* Prof. J. STANLEY GARDINER, *M.A., F.R.S., F.L.S.*) (Plate 45.) 409

PART XX.—FEBRUARY, 1913.

Titlepage, Contents, and Index 427

ERRATA.

Page 2, line 5, for *Alexandræ* read *Alexandri*.
,, 84, line 5 from bottom, for *Gynerium argenteum*, Linn., *read* Nees.
,, 91, fig. 23, for *adamanica* read *andamanica*.
,, 195, line 24, for *Illipe Malabrorum* read *I. Malabarorum*.
,, 209, line 24, for *pulvillus* read *pulvilla*.
,, 215, line 24, and p. 216, line 25, for *pedatilobata* read *pedatiloba*.
,, 224, line 18, for *phyllanthus* read *phyllanthos*.

2nd Ser. BOTANY.] [VOL. VII. PART 1.

THE TRANSACTIONS OF THE LINNEAN SOCIETY OF LONDON.

AN ACCOUNT OF THE JAMAICAN SPECIES OF LEPANTHES.

BY

WILLIAM FAWCETT, B.Sc., F.L.S., AND A. B. RENDLE, M.A., D.Sc., F.L.S.

Bot. Garden
1913

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

December 1904.

TRANSACTIONS

OF

THE LINNEAN SOCIETY.

I. *An Account of the Jamaican Species of* Lepanthes.

By WILLIAM FAWCETT, *B.Sc., F.L.S., and* A. B. RENDLE, *M.A., D.Sc., F.L.S.*

(Plates 1 & 2.)

Read 16th June, 1904.

LEPANTHES is a genus of the *Pleurothallis* group of monandrous Orchids, containing about fifty known species generally with a very restricted range on the mountains of Tropical America and the West Indies. So far as our present knowledge goes, the Andes of Peru and Ecuador represent the area richest in species; others are found on the Andes of Colombia, the mountains of Venezuela and Guiana; several species occur on the mountains of Central America and Equatorial Mexico; and some of the Jamaican species occur also in Cuba. Thus the genus is evidently a widespread Equatorial American alpine; the mountains of Jamaica and Cuba probably represent the limit of its northward range. Further research will doubtless result in a considerable increase in the number of species; thus Grisebach in the 'Flora of the British West Indies' enumerates six, while our account of the Jamaican forms includes twelve species.

Most of the specimens come from the Blue Mountain range, which is situated at the eastern end of Jamaica, running in an east-and-west direction. The rainfall towards its eastern limit is as much as 200 inches annually. The elevation reaches 7423 feet at the Peak (rainfall 175 inches), falling suddenly to the west to 5550 at Portland Gap, rising again westwards to Main Ridge Peak and John Grant Peak, falling to 5600 at Newhaven Gap, where the rainfall is about 150 inches, and still lower to Morse's Gap (4943 feet), whence it rises to 6000 feet in John Crow Peak. A road leads from Bellevue, Cinchona, which is on a spur of the range running southwards (rainfall 103 inches, elevation 5000 feet), over Morse's Gap, and then gradually downwards to the sea-coast, passing Vinegar Hill (3950 feet) and Claverty Cottage (2250 feet). From Morse's Gap there is a sudden and deep fall to the head-waters of the Mabess River, and collectors reach its banks (2000 to 3500 feet) either by descending by a track from

John Crow Peak or from Vinegar Hill. The localities labelled Mabess River refer not only to its actual banks, but to points in its valley descending from John Crow Peak. Moy Hall (Ellen Aire) lies directly south of the Blue Mt. Peak.

The Blue Mountains are clothed to the very summits with trees—*Clethra tinifolia*, *C. Alexandræ*, *Prunus occidentalis*, *Podocarpus Urbanii*, *Solanum punctulatum*, *Eugenia fragrans*, *Alchornea latifolia*, and the tree-ferns *Cyathea elegans*, *C. pubescens*, *C. concinna*, *Alsophila armata*, *A. parvula*, *A. aspera*, and *A. pruinata*. The stems of trees and tree-ferns are covered with Mosses and Hepaticæ, amongst which grow species of *Hymenophyllum* and *Trichomanes*, of *Polypodium* and *Asplenium*, together with species of *Pleurothallis* and *Lepanthes*. This mass of epiphytic growth is generally dripping with moisture.

Lepanthes is very closely allied to the much larger Tropical American mountain genus *Pleurothallis*, from which it is distinguished by the great development of the petals in the antero-posterior plane (they are generally several times broader than long) and in the union and close connection of the lip and column.

The plants are small, often minute herbs, and rarely exceed more than a few inches in height. The numerous slender, often filiform stems spring from a short rhizome, which is buried in the growth of moss, lichen, &c. attached to the bark of the tree on which the orchid is epiphytic. The moss-growth forms an efficient water-storing area, and is permeated by the numerous long slender roots of the epiphyte.

As in *Pleurothallis*, each shoot bears a single foliage-leaf, which springs more or less at right angles at the top of the stem and subtends the solitary or often numerous fascicled racemes. The stem is clothed throughout its length by a regular succession of narrow tubular sheaths, each of which ends in an obliquely trumpet-shaped mouth lined with a fringe of cilia; these sheaths are longitudinally striate and the projecting lines are often more or less hairy. The foliage-leaf is elliptical in shape, sometimes broadening to orbicular; the blunt or more or less acute or acuminate apex ends in three minute teeth, the base narrows into a scarcely perceptible stalk.

The flowers are borne on the upper part of the thread-like flowering axis, in a lax few-flowered raceme, or crowded in two rows. They are evidently short-lived and fall very readily, so that in herbarium specimens they are frequently absent. Owing to their very small size and the often complicated structure of the petals and lip, they are very difficult to examine when once dried; the descriptions which follow have, with two exceptions, been drawn up with the help of living specimens. The sepals form the most conspicuous part of the flower; they are ovate in shape and united at the base, from which they spread horizontally: the two lateral sepals are united for a portion of their length, which varies in different species; the tips are blunt or more or less acute, sometimes drawn out into short tails.

There is considerable variety in the degree of union of the two lateral sepals: in *L. bilabiata* their free portions are parallel, and they constitute an upper lip, which is opposed to the large concave median sepal and gives the flower its characteristic two-lipped form.

The fundamental colour is yellow, but the sepals are often blotched, streaked, or

flushed with crimson, or, as in *Lepanthes sanguinea* and *L. obtusa*, crimson throughout. In *L. divaricata* the colour of the sepals has been noticed to vary with the age of the flower. When the flower opens it is a transparent light yellow slightly shaded with crimson down the centre, but as the flower grows older the crimson extends almost to the edges, showing very little of the yellow. This may occur in other species in which the sepals are described as both yellow and crimson. The same colour-scheme holds with the petals and lip, but the tendency to crimson is more marked in the petals and still more marked in the lip.

The colour of the column was not always noted, but seems to be generally crimson. Crimson, often associated with yellow, also characterizes allied genera of Orchids inhabiting the mountains of Equatorial America. It is frequent in *Pleurothallis* and practically universal in *Masdevallia*.

The petals, which are much smaller than the sepals, show a greater variety in form. In *L. concolor* they are broadly deltoid, but generally are elongated in the vertical plane of the flower, forming narrow anterior and posterior lobes, while the length of the petal, from its base or point of insertion to the almost obsolete apex, is much reduced. The lobes vary in length, breadth, and form, but the two are generally similar. The most striking differences occur in the minute lip, which is inserted at or above the base of the short column. In several species it is a comparatively simple structure. Thus in *L. bilabiata* (Pl. 1. fig. 3) it is deeply concave and shelters the column by its elevated sides; in *L. quadrata* (fig. 13) the relatively large slightly concave subquadrate anterior portion is prolonged posteriorly into two blunt lobes which embrace the column. In *L. concolor* (fig. 6) and *L. tridentata* (fig. 11) the anterior portion is less developed, while the lateral lobes are large and embrace the column or stand parallel with its sides. In the remaining Jamaican species the anterior lobe is almost or quite suppressed, and the two lateral lobes are differentiated into a narrower lower portion, which is appressed to the sides of the column and expands above the middle into a fleshy surface developed in the antero-posterior plane of the flower and generally more or less lanceolate in outline; the fleshy surfaces embrace the sides and back of the column, the pointed end projecting anteriorly and the broader lobes meeting behind. These varying shapes of petals and lip are doubtless intimately connected with the pollination of the flower, but on this point we have no information. Observations in the field on such minute flowers will require much care and involve considerable expenditure of time. The pollinia, in the Jamaican species, are remarkably uniform in shape—pyriform, with rather long caudicles.

The capsule is generally shortly obovoid in shape, and longitudinally ridged or winged; the seeds, so far as we have observed, are colourless and linear-oblong to spindle-shaped. Their dissemination is aided by the hygroscopic movements of the numerous colourless elater-like hairs which line the walls of the interior of the capsule.

The name *Lepanthes* is derived from the Greek λέπος (bark) and ἄνθος (flower), "because plants of this genus grow on bark of trees" (Swartz, in Nov. Act. Reg. Soc. Sci. Upsal. vi. 85).

Note.—A large number of the specimens have been collected by Mr. W. Harris. A fine series has been placed in the Herbarium, British Museum. The figures are from an excellent series of drawings from living plants by Miss Helen Adelaide Wood.

LEPANTHES, Swartz, in Nov. Act. Reg. Soc. Sci. Upsal. vi. 85 (1799), t. 5. fig. 6; in Schrad. Journ. Botan. ii. 240 (1799) (*Lepantes*); in K. Vetensk.-Akad. Nya Handl. xxi. 249 (Jul., Aug., Sept. 1800); et in Fl. Ind. Occ. iii. 1555 (1806); Benth. & Hook. Gen. Pl. iii. 491 (1883).

Herbæ parvæ vel pusillæ, epiphyticæ; caules e rhizomate tenues, erecti, apice unifoliati, arcte vaginati. *Folium* sessile vel subsessile, rigidum, lanceolatum vel ellipticum, interdum orbiculare, apice tridenticulatum. *Racemi* axillares solitarii vel fasciculati; flores pauci vel plures distiche aggregati, sæpius minuti. *Sepala* patentia, ovata, subæqualia, basi plus minus connata. *Petala* minuta, unguis brevis columnæ basi adnatus, limbus valde latior quam longus. *Labellum* ad basin columnæ vel supra basin adnatum, forma valde diversum, interdum concavum vel cum lobo anteriore et lobis binis posterioribus simplicibus, sæpius lobo anteriore plus minus obsoleto et lobis lateralibus erectis, columnæ parallelis, superne crassiusculis et columnam amplectentibus. *Anthera* terminalis, opercularis, sæpius obovata; pollinia 2, cerea, pyriformia, longius pedicellata. *Capsula* obovoidea.

A. Lip simple. (Plants small, less than 3 inches high, with elliptical not acuminate leaves.)
- Lip concave, nearly round in outline; dorsal sepal hooded . . . . 1. *L. bilabiata.*
- Lip prolonged posteriorly into two lobes.
  - Lobes of lip short, blunt; racemes usually shorter than the leaves . . . 2. *L. concolor.*
  - Lobes spathulate; racemes longer than the leaves . . . . 3. *L. rotundata.*
  - Lobes long and slender.
    - Apex of lip mucronate; lobes appressed to the long slender column . . 4. *L. tridentata.*
    - Apex of lip emarginate; column short, broadening upwards . . . . . 5. *L. quadrata.*

B. Lip with side lobes more or less erect and expanding above into a broad fleshy area.
- Leaves not acuminate; plants less than 3 inches high, sheaths hairy at the mouth only.
  - Lateral sepals connate at base only; racemes longer than the leaf. . . . 6. *L. pulchella.*
  - Lateral sepals connate to the middle; petals and lip downy; racemes longer than the leaf . . . . 7. *L. Loddigesiana.*
  - Lateral sepals connate for ⅔ their length; racemes shorter than the leaf. . . . . 8. *L. sanguinea.*
- Leaves often orbicular; plants less than 3 inches high, sheaths strongly hirsutulous . . . . 9. *L. cochlearifolia.*
- Leaves with more or less acuminate apex; plants generally larger, more than 3 inches high.
  - Lateral sepals united as far as the middle.
    - Posterior lobes of petals elliptic, with rounded apex and generally much larger than the short acute anterior lobes . . . . 10. *L. concinna.*
    - Posterior and anterior lobes of petals subequal, trapezoid . . . . . . 11. *L. obtusa.*
  - Lateral sepals divaricate, united for ⅓ their length . . . . 12. *L. divaricata.*

1. LEPANTHES BILABIATA, sp. nov. (Plate 1. figs. 1–4.)

Herba pusilla, caulibus tenuibus folia anguste elliptica excedentibus; vaginæ ore acuminato ciliolatæ, striis muriculatis. *Racemi* sæpe plures fasciculati, quam folia

duplo breviores, floribus laxis paucis, bracteolis glabridis. *Sepalum* posticum alte concavum, mucronatum, sepala lateralia parallela in labium anticum postico simile sed minus et bifidum connata. *Petala* apice obscura, lobo antico breviter subulato, quam postico elliptico paullo minore. *Labellum* concavum, columnam amplectens, suborbiculare, basi cordatum, apice bidenticulatum vel sæpe tridenticulatum. *Columna* brevis, superne dilatata. *Anthera* obovata, alte emarginata. *Capsula* subglobosa, gibbosa, 6-carinata.

Stems 1–2·5 cm. long. Leaves narrowing at the base into a short stalk 2–3 mm. long, blade 10–17 mm. long, 4–7 mm. broad, obscurely apiculate. Bracteoles subacute, almost glabrous. Dorsal sepal dark crimson-purple, shaped like an open basket, 3 mm. long and as broad; the lateral sepals reddish, united for ⅔ their length and forming an anterior lip 2·5 mm. long and scarcely as wide as the dorsal, apices acute. Petals about 3 mm. broad, the larger posterior lobes coloured like the dorsal sepal, the anterior whitish yellow. Lip whitish yellow, about 2 mm. long and somewhat broader when flattened, completely sheltering the column with its curving sides. Capsule markedly asymmetrical, keels conspicuous.

Hab. Mabess River, at 3000 & 4000 ft., *W. Harris*, Feb. 22 *, Nov. 25; near John Crow Peak, above Mabess River, *W. Fawcett*, Sept. 5, *W. Harris*, Jan. 24 (flower and fruit).

2. Lepanthes concolor, sp. nov. (Plate 1. figs. 5–7.)

Herba parva, caulibus folia elliptica vel rotunde elliptica valde excedentibus; vaginæ ore striisque minute ciliolatæ. *Racemi* 1–3-fasciculati, quam folia sæpissime breviores, bracteis glabridis, floribus laxis paucis, pallide luteis. *Sepala* ovata, lateralia ad medium connata, glabra. *Petala* obverse deltoidea, apice inæqualiter concava. *Labellum* antice retusum et obtuse apiculatum, lobis crassis columnam amplectentibus. *Columna* brevis, superne dilatata. *Capsula* oblique obovoidea.

Stems generally from 2–3 cm. long; sheaths conspicuously ridged, the mouth sharply acute. Leaf-blade generally 10–15 mm. long by 5–8 mm. broad. Racemes 6–8 mm. long, bearing one or two open flowers. Sepals pale yellow, 3 mm. long, the dorsal 2·5 mm. broad, the lateral barely 1·5 mm. at the point of union. Petals pale yellow, a little over 1 mm. long and slightly broader. Lip shallowly retuse anteriorly with a short apiculus, the side lobes extended backwards and embracing the column; 1·5 mm. broad anteriorly, side lobes 1 mm. long. Capsule 6-keeled, 4 mm. long, 3 mm. broad.

Hab. Newhaven Gap, at 5600 ft., *W. Harris*, Feb. 10 (flower and fruit); Rose Hill, 4000 ft., *W. Harris*, Oct. 30; Morse's Gap, *W. Fawcett*, Nov. 3; ridge above Morse's Gap, at 5400 ft., *W. Harris*; Blue Mountains ridge, *W. Fawcett*, Aug. 28; Moy Hall, *C. F. Sullivan*, Sept. 14.

The plant from Rose Hill differs from the other specimens in having the racemes longer than the leaf; they reach nearly 2 cm. The flowers, however, resemble those of specimens from other localities.

* The dates given may be taken to represent, unless otherwise stated, the time at which the plant is in flower. Unfortunately the flowers drop so readily that they are often absent in herbarium specimens which were presumably collected when in flower.

3. LEPANTHES ROTUNDATA, Griseb. Fl. Brit. West Ind. 610 (1864).

Herba parva, caulibus folia elliptica valde excedentibus; vaginæ ore minute ciliolatæ. *Racemi* fasciculati, interdum solitarii, quam folia longiores. *Sepala* deltoidea, lateralia alte connata. *Petala* obverse deltoidea, sepalis multo minora. *Labelli* lobi divergentes spathulati, medio columnæ adnati.

Stems about 5 cm. long, sheaths with a subulate minutely ciliate limb. Leaf 12–16 mm. long by 8 mm. broad. Flowers 4 mm. long. Lateral sepals cohering below the bidentate summit.

Hab. Jamaica, *Macfadyen.*

We have not seen this plant.

4. L. TRIDENTATA, Sw. in Nov. Act. Reg. Soc. Sci. Upsal. vi. 86 (1799); in Schrad. Journ. Botan. ii. 241 (1799); in K. Vetensk.-Akad. Handl. xxi. 249 (1800); et in Fl. Ind. Occ. iii. 1561 (1806); Wickstr. Adnot. Bot. Sw. t. 2. fig. 2 (1829); Reichenb. f. Xenia Orchid. i. 143 (1856); Griseb. Fl. Brit. West Ind. 610 (1864), excl. syn. (Plate 1. figs. 8–11).

Epidendrum tridentatum, Sw. Prodr. 125 (1788).

Type in Herb. Mus. Brit.

Herba parva, caulibus folia elliptica pluries excedentibus; vaginæ muriculatæ. *Racemi* 2–3-fasciculati, floribus pluribus approximatis. *Sepala* ovato-acuminata, lateralia ad medium connata. *Petala* subrhomboidea sed transverse extensa, cum basi truncata et marginibus superioribus leviter concavis. *Labellum* antice rotundatum et subito mucronatum, postice cum lobis binis erectis subulatis columnæ appressis et æquilongis. *Columna* pro genere longa. *Capsula* subglobosa, prominenter carinata.

Stem 2–7 cm. long; sheath-margins ciliolate, longitudinal ribs muriculate. Leaves somewhat narrowly elliptical and tapering at base and apex, 15–24 mm. long by 5–7 mm. broad. Racemes a little shorter than the leaf, rarely solitary, generally 3 or 4 together; flowers numerous, distichous, and closely crowded in the upper half or third. Sepals yellowish, 2·5 mm. long, the dorsal 1 mm. broad, the lateral pair 1·5 mm. broad at the point of union. Petals yellowish, suberect, the hinder lobes embracing the column and meeting behind it. Lip crimson, the awl-shaped lobes erect and closely appressed to the sides of the column. Column pink, scarcely dilated at the apex, 1 mm. long. Anther white, roundly obcordate. Capsule with prominent deep purple keels, 5 mm. long.

NOTE.—Swartz (Fl. Ind. Occ. *l. c.*) says "corollæ purpureo-luteæ."

Hab. Blue Mountains, *Swartz.* Near Mabess River, at 4000 ft., *W. Harris,* Feb. 22; Moy Hall, *C. F. Sullivan,* Sept. 14; Morse's Gap, 5000 ft., *W. Harris,* May; below John Crow Peak, north side, at 5200 ft., *W. Harris,* April 29; John Crow Peak, *W. Fawcett,* Aug. 18, and near, *W. Harris,* Jan. 24 (in flower and fruit); near Newhaven Gap, *W. Fawcett,* Sept. 1.

Distribution. Cuba.

5. LEPANTHES QUADRATA, sp. nov. (Plate 1. figs. 12–14.)

Herba pusilla, caulibus folia elliptica paullo excedentibus; vaginæ in ore minute ciliolatæ, striis minutissime muriculatæ. *Racemi* sæpissime plures fasciculati, interdum solitarii, quam folia plus duplo breviores, bracteis glabris, floribus laxis paucis. *Sepala* ovato-acuminata, ventricosa, margine nervisque ciliolata, lateralia paullo minora, ⅓-connata. *Petala* apice obtusa, lobis æquilongis, posticis oblanceolatis convergentibus, anticis linearibus. *Labellum* subquadratum, antice rotundatum et emarginatum, postice in lobis subparallelis linearibus subacutis productum. *Columna* brevis, superne dilatata. *Capsula* obovoidea.

Stems to 2·5 cm. long; the margin of the spreading mouth of the sheaths and the longitudinal striæ bear minute cilia and excrescences. Leaves 10–16 mm. long by 4–9 mm. broad. Sepals purplish crimson, 3 mm. long, concave, the ciliate veins somewhat prominent on the back, and passing above into the acuminate short-tailed tip. Petals with a short blunt apex; lateral lobes blunt, the anterior narrower, 1·5 mm. wide. Lip consisting of a large anterior subquadrate portion attached by a very short insertion on the column-base, with a shallowly notched broadly rounded apex, and produced behind into a pair of bluntly tapering narrow lobes about equal in length to the anterior portion. Anther ovoid rectangular, emarginate.

Hab. Near Mabess River, at 3500 feet, *W. Harris*, Feb. 22, April 12; near John Crow Peak, *W. Harris*, Jan. 24.

6. L. PULCHELLA, Sw. in Nov. Act. Upsal. vi. 86, t. 5. figs. 6 *c*, *d*, *e* (1799); in Schrad. Journ. Botan. ii. 241, t. 2. 2. figs. *c–f* (1799); in K. Vetensk.-Akad. Handl. xxi. 249 (1800); et in Fl. Ind. Occ. iii. 1559 (1806); Wickstr. Adnot. Bot. t. 2. fig. 3 (1829); Reichenb. f. Xenia Orch. i. 145 (1856); Griseb. Fl. Brit. West Ind. 610 (1864). (Plate 1. fig. 15.)

Epidendrum pulchellum, Sw. Prodr. 125 (1788).

Type in Herb. Mus. Brit.

Herba pusilla, caulibus folia breviter vel rotunde elliptica, acuta, subæquantibus; vaginæ ore solum ciliolatæ, acutæ. *Racemi* fasciculati, folia excedentes, floribus pluribus sæpe laxis. *Sepala* ovata, longe acuminata, ciliolata, basi connata. *Petala* apice obscura, lobis subæqualibus subtriangularibus, margine ciliolatis. *Labellum* sub medio columnæ insertum, lobo medio minuto, lobis lateralibus supra medium utrinque expansis, columnam cum lobis incrassatis obtusis amplectentibus.

Stems 1 cm. or less in length; the enveloping sheath-tubes glabrous. Leaves, including the short stalk, 10–14 mm. long by 5–6 mm. broad, the central tooth at the apex longer than the lateral teeth. Racemes generally 2–5, rarely solitary, exceeding the leaf, 1·5–2 cm. long; 3 or 4 flowers appear at the same time. Sepals yellow, the lateral with a small crimson spot at the base, the posterior crimson along the midrib, 6–8 mm. long by 2–3 mm. broad, the lateral pair connate at the base only. Petals crimson, inclining to yellow at the margin, apex indicated by an inconspicuous notch or tooth; the subequal lobes varying somewhat in shape, especially in breadth, more or less bluntly and

asymmetrically triangular, the outer edges of the two forming an almost continuous line, 2·2–4 mm. wide. Lip crimson, inserted above the base of the column; the middle lobe minute, apparently shortly bifid; the side lobes appressed to the column, spreading at the middle to form a crimson upper surface which embraces the column, projecting back and front in a short lobe of which the anterior is the less blunt; upper surface minutely ciliolate, 1–1·5 mm. from back to front. Column crimson, 1 mm. long. Anther subglobose, emarginate. Capsule (unripe) 6-keeled, 5 mm. long.

Hab. Top of Catherine Mt., *Swartz.* Near Mabess River, Portland, at 3000 ft., *W. Harris*, Nov. 22; John Crow Peak, *W. Harris*, Jan. 24, *W. Fawcett*, Sept. 5, Aug. 18; Newhaven Gap, at 5600 ft., *W. Harris*, Feb. 10; Morse's Gap, *W. Harris*, May; ridge above Morse's Gap, 5300 ft., *W. Harris*, April 22; Moy Hall, *C. F. Sullivan*, Sept. 14.

NOTE.—Swartz's figure in Wickstr. Adnot. *l. c.* represents a larger plant than any that we have seen, having stems to 2 cm. and leaves to nearly 2 cm. long by 1·8 mm. broad.

7. LEPANTHES LODDIGESIANA, Reichenb. f. Xenia Orchid. i. 145 (1856).

L. tridentata, Lindl. Bot. Reg. 1762 (1835), non Swartz; Griseb. Fl. Brit. West Ind. 610 (1864), "a form with reduced stems."

Herba pusilla, caulibus quam folia elliptica sæpissime brevioribus; vaginæ læves. *Racemi* solitarii, folia excedentes, 1–2-flori. *Sepala* ovata, acuta, lateralia ad medium connata. *Petala* sepalis dimidio breviora, cum apice obsoleto, tomentosa, lobis anticis obtusis, posticis longioribus, subtriangulis, acutis. *Labellum* basi concavum et basi columnæ adnatum, trilobum, lobis lateralibus ascendentibus, ciliatis, columnam amplectentibus, lobo medio incurvo, minimo, breviter acuto, obscurius ciliato. *Columna* brevis, bicornuta.

Stems varying "from 2 lines to 2 inches in length." Leaves "1½ inch long," with shortly acute apex, and tapering at the base into an obscure petiole. Racemes about half as long again as the leaves. Sepals equal, the dorsal purple with a yellow edge, the lateral yellow slightly tinged with purple, the surface frosted with brilliantly glittering tubercles. Petals deep purple, downy. Lip yellowish downy, the lower part tinged with purple, the upper surface of the lateral lobes somewhat lanceolate in shape, parallel with and protecting the sides of the column, which is prolonged above into a pair of small lateral horns.

Hab. "A native of the highest parts of the mountains of Jamaica, where it is found growing on the bark of trees, among mosses."

We have not seen this plant. The description is compiled from the account and figure in the 'Botanical Register,' where it was assigned by Lindley to *L. tridentata*, Swartz. It differs widely from that species in the form of the petals and lip, which resemble somewhat those of *L. pulchella*; from the latter it differs in the union of the lateral sepals, which are moreover acute, not acuminate.

8. LEPANTHES SANGUINEA, Hook. in Curtis, Bot. Mag. 4112 (1844); Reichenb. f. Xenia Orch. i. 147 (1858); Griseb. Fl. Brit. W. Ind. 611 (1864). (Plate 1. figs. 16, 17.)

Herba pusilla, caulibus quam folia elliptica brevioribus; vaginæ ore ciliolatæ acutæ, in striis longitudinalibus muriculatæ. *Racemi* pauciflori, plures, congesti, quam folia triplo vel quadruplo breviores, bracteolæ acutæ plus minus hirsutulæ. *Sepala* ovata, subacuta, glanduloso-ciliata, lateralia $\frac{2}{3}$-connata. *Petala* utrinque subæqualiter extensa, lobis oblongis vel oblongo-ellipticis, ciliolatis. *Labellum* trilobum, lobo medio brevi, ciliato, lobis lateralibus ad latera columnæ appressis, supra medium expansis et transverse ellipticis, columnam amplectentibus. *Columna* brevis, superne dilatata.

Stems 1 cm. or less in length. Leaves subsessile, 12–18 mm. long, 5–8 mm. broad, shortly apiculate. Racemes 4–6 mm. long; bracteoles more or less hirsutulous on dorsal nerve and margin. Sepals magenta-crimson, 4 mm. long, the dorsal 2·5–3 mm. wide. Petals rose-coloured and crimson, $\frac{2}{3}$ mm. long, 2·5–3 mm. wide, the apex forming an almost straight line or slightly retuse. Lip deep crimson, the upper margins of the lateral lobes elliptical to elliptical-lanceolate. Anther obovately orbicular, emarginate. Capsule not seen.

Hab. Near Mabess River, growing on trees at 4000 ft., *W. Harris*, Feb. 22, Nov. 25; near John Crow Peak, *W. Harris*, Jan. 24; Road to John Crow Peak, at 5300 ft., *W. Harris*, April 29; Mount Diabolo, at 2500 ft., *W. Harris*, May 21.

Mount Diabolo is of limestone formation, near the centre of the island. There are frequent showers but no running streams.

9. L. COCHLEARIFOLIA, Sw. in Nov. Act. Upsal. vi. 86, t. 5. figs. 6 *a*, *b* (1799); in Schrad. Journ. Bot. ii. 241, t. 2. 2. figs. *a*, *b* (1799); in K. Vetensk.-Akad. Handl. xxi. 249 (1800); et in Fl. Ind. Occ. iii. 1563 (1806); Wickstr. Adnot. Bot. t. 2. fig. 1 (1829); Reichenb. f. Xenia Orch. i. 148 (1858); Griseb. Fl. Brit. W. Ind. 611 (1864). (Plate 2. figs. 18–21.)

Epidendrum cochlearifolium, Sw. Prodr. 126 (1788).

Type in Herb. Mus. Brit.

Herba parva; caules folia orbicularia vel rotunde elliptica vel interdum elliptica longe excedentes; vaginæ hirsutæ cum ore late aperto et apice acuto. *Racemi* sæpissime plures fasciculati, quam folia plus dimidio breviores; flores pauci, laxi. *Sepala* ovata, acuminata, lateralia $\frac{1}{3}$-connata. *Petala* apice obtusa, transverse rhomboidea, utrinque in cornu longum subincurvum producta. *Labelli* lobi laterales supra medium expansi columnam amplectentes, postice obtusi, antice acuti. *Columna* brevis, sub apice dilatata.

Stems 2–6 cm. long; the ridges on the sheath and the margin of the wide open mouth bearing numerous stiffish white hairs. Leaves varying in shape from orbicular to broadly elliptical, shortly apiculate and narrowing at the base into a short stalk, the marginal and three principal veins uniting below the apex; blade 15–25 mm. long, 10–18 mm. broad, sometimes tinged with purple. Racemes generally less than 1 cm. long. Sepals

purple, 5–6 mm. long, 3–3·5 mm. broad. Petals brick orange yellow tinged with crimson towards the centre, with a short blunt apex and a short rhomboidal body ·65 mm. long, shortly toothed at the lower corners and drawn out at the upper into longer tapering upcurving horns; 6 mm. wide, including the horns. Lip purplish crimson; median lobe short; lateral lobes appressed to the sides of the column and expanding above into a narrowly lanceolate surface, produced anteriorly round the back of the column and ending behind in a roundish base. Anther obovately rectangular, emarginate.

Swartz describes this species as the most beautiful of the genus.

Hab. "In summis montibus Jamaicæ australis, in truncis arborum necnon rupibus muscis vestitis." "Floret ultimis mensibus anni." *Swartz* (Fl. Ind. Occ. iii. 1563–4). Near Mabess River, 3500 and 4000 ft., *W. Harris*, in flower Dec.–April; John Crow Peak, slopes and spur, 100 to 300 ft. above Mabess River, *W. Fawcett*, Sept. 5; near John Crow Peak, *W. Harris*, Jan. 24; Brown's Town, St. Ann, *Miss T. Moulton-Barrett*, March.

10. Lepanthes concinna, Sw. in Nov. Act. Upsal. vi. 85 (1799); in Schrad. Journ. Botan. ii. 241 (1799); in K. Vetensk.-Akad. Handl. xxi. 249 (1800); et in Fl. Ind. Occ. iii. 1557 (1806); Wickstr. Adnot. Bot. t. 2. fig. 4 (1829); Reichenb. f. Xenia Orch. i. 150 (1858); Griseb. Fl. Brit. W. Ind. 611 (1864). (Plate 2. figs. 22–25.)

Epidendrum ovale, Sw. Prodr. 125 (1788).

Herba specierum Jamaicensium maxima; caules erecti vel suberecti, folia elliptica acuminata perpluries excedentes; vaginæ tenues in ore acuto et striis minute ciliolatæ. *Racemi* foliis breviores, sæpe plures fasciculati, floribus pluribus distichis, bracteolis glabris, tenuiter acuminatis. *Sepala* late ovata, subacuta, lateralia ad medium connata. *Petala* cum apice obsoleto, lobis posticis majoribus ellipticis obtusis, post columnam imbricatis, anticis lanceolatis, acutis, divergentibus. *Labelli* lobus anticus obsoletus, lobi laterales erecti, supra medium incrassati et lanceolati columnam amplectentes. *Columna* brevis, superne dilatata. *Capsula* obovata, apice gibbosa.

The slender wiry stems spring from a short woody rhizome and may reach 20 cm. in length, but barely 1 mm. in diameter. By the perishing of the sheaths, the older stems often become bare, exposing the cylindrical internodes, which often have a reddish tinge. Leaves shortly stalked, generally 4 to 7 cm. long by 1·5 to 2·8 cm. broad. Racemes to 5 cm. long; besides the flowering one, a number (sometimes as many as fifteen) of dried peduncles of former flowering seasons form an often dense fascicle in the leaf-axil; flowers 8–16, closely distichous in the upper 6–12 mm. Sepals tawny yellow, sometimes flushed with crimson, 3 mm. long; the dorsal 3 mm. wide, the lateral 2 mm. The blunt posterior lobes of the petals overlapping behind the column, orange, shaded on the inner side with crimson or purple; the shorter anterior lobes yellow. Lip crimson or purplish; mid-lobe suppressed, the lateral lobes suberect to the middle and then expanding to flattened lanceolate surfaces which embrace the column and overlap behind it. Column crimson. Anther obovate, apex retuse. Capsule 4 by 3 mm., the pedicel elongating considerably in the fruit (7 mm. in one specimen).

Hab. Top of the mountains, *Swartz.* Growing on the bark of trees, Mabess River, at 4000 ft., *W. Harris*, Feb. 15, Nov. 25, and at 3500 ft. April 12; below John Crow Peak, north side, at 5000 ft., and John Crow Peak, *W. Harris*, Jan. 24, *W. Fawcett*, Sept. 5; below Vinegar Hill, at 3500 ft. altitude, *W. Harris*, Oct. 25; Morse's Gap, at 5000 ft., *W. Harris*, Oct. 21; Greenhill, at 3000 ft., *A. Moore*, Nov. 19; Ridge above Morse's Gap, at 5500 ft., *W. Harris*, April 22.

Distribution. Cuba (*Wright*, 1510 in part.).

N.B.—Wright's specimen at the British Museum is a mixture; one piece in fruit is evidently *L. concinna*, the rest is *L. tridentata*, Sw.

Var. OBTUSIPETALA, var. nov.

A typo differt sepalis paullo acutioribus, et lobis petalorum anticis obtusis.

Hab. Portland Gap, 5550 ft., *W. Fawcett*, June 29.

The posterior lobe of the petals is slightly shorter than in the species proper, and the two lobes are more nearly alike in form and size, suggesting an approach to the following species *L. obtusa*, in which, however, the subequal lobes have a characteristic deltoid form.

11. LEPANTHES OBTUSA, sp. nov. (Plate 2. fig. 26.)

Herba habitu *L. concinnæ*, sed folia sæpius paullo angustiora et in facie superiore læte violacea. *Racemi* foliis plus duplo breviores, plures fasciculati; flores laxi, pauci. *Sepala* sanguinea, late ovata, breviter acuta, lateralia ad medium connata. *Petala* cum apice obscuro, lobis subæqualibus lineari-deltoideis, obtusis. *Labelli* lobi laterales erecti, supra medium incrassati et lineari-lanceolati columnam amplectentes. *Columna* brevis, superne dilatata. *Capsula* late obovoidea.

The habit of the plant is that of *L. concinna*, but often much smaller. The slender stems reach 10–12 cm. in length; the leaves are somewhat narrowly elliptical and acuminate, generally between 4·5 and 5·5 cm. long by 1·2 to 2 cm. broad. Racemes 2 cm. long. Sepals crimson, 6 mm. long by 6 mm. broad, the connate lateral pair 6·5 mm. below the point of union. Petals 3·5 mm. wide, crimson like the sepals, as is also the lip. Capsule 5 mm. long.

Closely allied to *L. concinna*, but distinguished by the crimson colour of the sepals and the bluntly linear-deltoid lobes of the petals; the leaves are also narrower and have a bright violet upper face.

Hab. Newhaven Gap, at 4000 ft., growing on trees, *W. Harris*, Feb. 10; Greenhill, at 3000 ft., *A. Moore*, Nov. 19; Portland Gap Road, *W. Fawcett*, Mar. 26; Road to Vinegar Hill from Morse's Gap, at 4000 ft., growing on decaying logs, *W. Harris*, April 29.

12. L. DIVARICATA, sp. nov. (Plate 2. figs. 27–29.)

Herba sæpe major, caulibus folia elliptico-acuminata pluries excedentibus; vaginæ in ore aperto et in striis minute ciliolatæ. *Racemi* plures fasciculati, quam folia

interdum breviores interdum longiores; flores densi, plures. *Sepala* ovata, acuminata, lateralia ⅓-connata, divaricata. *Petala*, apice obscuro, utrinque subæqualiter extensa, lobis linearibus ad lineari-oblongis, obtusis vel obtusiusculis. *Labellum* cum lobo mediano obsoleto, lobis lateralibus ad latera columnæ appressis, supra medium expansis et lanceolatis (anteriore acutis), columnam amplectentibus. *Capsula* obovoidea.

Stems 2·5–10 cm. long, rarely longer (to 15 cm.) Leaves, including the short stalk, generally 2–3 cm., rarely to 4 cm., long, by 8–13 mm. broad, often purple beneath. Racemes 2–3·5 cm. long. Sepals with apices diverging, very variable in size, from 4–6 mm. long and from 2–4 mm. broad: colour varying with age; when the flower opens it is a transparent light yellow slightly shaded with crimson down the centre; as the flower grows older the crimson shading extends almost to the edges showing very little of the yellow. Petals 2·5–3·5 mm. broad, lobes ·75 to 1·5 mm. wide; upper half orange, lower half crimson, the crimson colour sometimes extending nearly to the edge. When the flower opens the tips of both lobes overlap, then they straighten, but in the old flower converge again; when the lobe-tips converge the apex of the petal appears distinctly acute, but when the petals are straight the apex is not evident. Lip crimson, with more or less orange shading; the upper margins of the lateral lobes lanceolate, with the pointed end anterior, the blunt end curving round behind the column. Column crimson; anther light purplish. Capsule 5 mm. long by 4 mm. in diameter, bearing six ridges.

Hab. Near Woodcutter's Gap, at 4000 ft., *W. Harris*, March 6; Portland Gap, *W. Fawcett*, Aug. 4; Morse's Gap, at 4800 ft., *W. Fawcett*, Oct.; Ridge above Morse's Gap, at 5300 ft., on tree-trunks, *W. Harris*, April 22; Newhaven Gap, at 4000 ft., *W. Harris*, Feb. 10; Blue Mountain Peak, at 7000 ft., *W. Harris*, May 31; John Crow Peak and neighbourhood, *W. Fawcett & W. Harris*, Aug. to April; Moy Hall, *C. F. Sullivan*, Sept. 14.

Var. MINOR.

Herba minor, foliis quam in typo minus acuminatis, floribus sanguineis.

Stems to 3 cm. long; leaves broadly elliptical, very shortly acuminate, rarely exceeding 1·5 cm. long by 1 cm. broad; racemes slightly longer than the blade, to 2 cm. long. Dorsal sepal 3 mm. long by barely 2 mm. broad, lateral sepals 3·2 mm. long. Petals less than ·5 mm. long, 2·5 mm. broad. Upper surface of lip-lobes lanceolate, acute, a little over 2 mm. long.

Hab. Moy Hall, *C. F. Sullivan*, Sept. 14.

EXPLANATION OF THE PLATES.

Plate 1.

Lepanthes bilabiata.

Fig. 1. Habit of plant, natural size.
2. Front view of flower, × 5.
3. Lip, × 7.
4. Petal, × 10.

Lepanthes concolor.

Fig. 5. Flower, flattened out, much enlarged.
6. Column and lip, × 15.
7. Petal, × 12.

Lepanthes tridentata.

Fig. 8. Leaf and raceme, enlarged.
9. Flower flattened out, enlarged.
10. Column, with lip and petals, not fully expanded, much enlarged.
11. The same, spread open, much enlarged.

Lepanthes quadrata.

Fig. 12. Leaf and inflorescence, enlarged.
Figs. 13, 14. Column, lip, and petals, from two positions, × 20.

Lepanthes pulchella.

Fig. 15. Flower, front view, much enlarged.

Lepanthes sanguinea.

Fig. 16. Flower and leaf, × 5.
17. Column, with lip and petals spread open, × 12.

Plate 2.

Lepanthes cochlearifolia.

Fig. 18. Plant, natural size.
19. Flower and leaf, × 3.
20. Column with lip, opened out, much enlarged.
21. Petal, straightened out, × 8.

Lepanthes concinna.

Fig. 22. Leaf, natural size.
23. Inflorescence, × 5.
24. Lip and column, much enlarged.
25. Petals, much enlarged.

Lepanthes obtusa.

Fig. 26. Column, with lip and petals spread open, × 8.

Lepanthes divaricata.

Fig. 27. Leaf, enlarged.
28. Column, with lip and petals spread open, × 15.
29. Side view of flower, with one petal and half of sepals removed, × 8.

West, Newman imp.

SPECIES OF LEPANTHES

SPECIES OF LEPANTHES

II. *The Morphology and Anatomy of the Stem of the Genus* Lycopodium.

By CHARLES EDWARD JONES, *B.Sc., F.L.S.*

(Plates 3–5.)

Read 7th April, 1904.

THERE have been in the past very few original communications restricted to an investigation of the genus *Lycopodium*, although between the years 1846 and 1874 several papers were published which dealt with special features, mainly for the purpose of comparison with allied genera, and, as a result, a general but fragmentary conception of the structure of Lycopods has been evolved, the substance of which has been incorporated into text-books, and occasionally additions have been made when the writers have preferred to get the facts first-hand. An explanation of the development of the peculiar root-like structure and a comparative description including the anatomical features of exotic species have never been published, and it is with the intention of providing a fuller comparative account of the stem and its anatomy and with the object of elucidating the formation of what may become a very complex vascular arrangement that this investigation was undertaken.

Turning to the early literature concerned with *Lycopodium*, the paper written by Hegelmaier (5) in 1872 stands out pre-eminently as a carefully prepared and reliable comparative survey of the characters of the commonest species (*Lycopodium clavatum, annotinum, alpinum, inundatum*, and *Selago*). Before Hegelmaier, one or two well-known botanists had published results. In 1846 Nägeli (1) was already endeavouring to decipher the structure of the growing apices in plants, and for this purpose examined the apex of the stem of *Lycopodium clavatum*. In this paper he refuted the impression which then prevailed that the vascular portion consists of one bundle, and pointed out that the vascular cylinder consists of a number of vascular strands in accordance with the number of protoxylems. He observed that the leaf-traces and the protoxylems differentiate simultaneously, and therefore concluded, not without considering other possibilities, that each vascular strand passes off into a leaf-trace. Nägeli's paper (3) gives an account of the root-development, more especially of the branching of the root-system, for *L. clavatum*. There is a figure of a very definite apical cell and a detailed account of the formation of root-hairs, but no definite information about the connection of the vascular cylinder in the root with that of the stem. Cramer (2) examined the apex of *L. Selago* and studied more particularly the leaf-arrangement. He showed that there is considerable variation, that sometimes the leaves fall on a spiral—of which the commonest is 2/9—and sometimes they are arranged in whorls; also he found that there is no relation between the number of leaves and the number of protoxylems. Before

publishing an account of the structure of *Lycopodium* in his text-book, Sachs (4) made observations for himself, and even if he was not the first to recognise the phloem-nature of the elements lying between the xylem-bands, he cleared away the idea of cambium-layers which is found in previous writings, and further he called attention to the sieve-tubes which lie in the centre of the phloem-bands. Two important papers appeared in 1872, that by Hegelmaier (5), which has already been mentioned, and the account by Russow (6) in the 'Vergleichende Untersuchungen.' The former paper is the most complete original account of the morphology which has been written, but is confined almost entirely to five species; the latter is a brief but pithy summary of the chief facts which the author observed in what was presumably a limited examination undertaken in the course of extensive comparative investigations. Russow's account of the structure is not altogether accurate; the statement appears (p. 129) that "the phloem (Phloem-körper) surrounds the whole of the xylem and penetrates it by radiating extensions which fill up the spaces between the xylem-bands"; as he mentions later that the protophloems alternate with the protoxylems, and that the differentiation of both phloem and xylem proceeds centripetally, it is evident that the "Phloem-körper" includes the phloem-sheath, which at that time might have been regarded as part of the phloem. At the same time he does not distinguish between them, although he could not fail to have seen the well-known iodine reaction; again, the numbers which he states for the protoxylems of the species must have been based upon cursory examination. Otherwise he presents a remarkably correct account of the structure of the different cells, including protoxylems, phloem-elements, and cortex. Hegelmaier's contribution is not so vigorous as that of Russow, but his conclusions have for the most part stood the test of later investigations undertaken with improved apparatus. It will be sufficient here to mention the chief items which he discusses:—(1) The bilateral character of most of the stems and branches which he examined, as shown externally and internally: although the arrangement of parallel bands was found to lie approximately in a horizontal position, he rejected the idea that this is caused by a force acting vertically; (2) descriptions and figures of the general configurations of the vascular structure and the want of proportion between leaf-traces and protoxylems; (3) the structure of the apex, which he finds to be devoid of an apical cell, and the methods of differentiation of tissues proceeding from the apex; (4) the numbers, arrangement, and development of the leaves; (5) the methods of branching; (6) the formation of the sporangia, and, finally, an account of the bulbils of *L. Selago* and the mucilage-cavities of *L. inundatum*. In 'Die Coniferen und Gnetaceen' (7), which was also published in 1872, Strasburger gave an account of his examination of the apex of *L. Selago*, and concluded that in *Lycopodium* there is not a single apical cell as in Ferns, but that a single cell gives rise to periblem and dermatogen and one or two cells form the origin of the plerome, so that the apex of the stem in *Lycopodium* would be intermediate between the single apical cell on the one hand and the three more or less definite meristems on the other. In this paper the author also published a description of the bulbils of *L. Selago*, which did not agree with that given by Hegelmaier, but in the following year, having repeated his observations (8), he was able to confirm Hegelmaier's results. In the 'Histologische Beiträge' (10),

Strasburger has treated of one or two features in the structure of *Lycopodium*. He begins (p. 458) by noting the similarity between the structure of the vascular cylinder in *Lycopodium* and *Selaginella*, and says that the "central cylinder of a *Lycopodium* may be regarded phylogenetically as a union of steles (similar to that found in *Selaginella*) and as gamostelic." This was written at a time when Van Tieghem's stelar conceptions received general acceptance, but a similar view is put forward in the morphological portion of the 'Text-book of Botany.' From this view of the structure of the vascular cylinder in *Lycopodium* I entirely dissent, and an explanation is offered in the course of the paper of the development of the complex structure from a simple form found in the seedling, with which the union of schizosteles is quite incompatible.

It cannot be said that the account of *Lycopodium* (13) which appeared in Engler and Prantl's 'Pflanzenfamilien' has added much to our knowledge of the genus; the figures (p. 579) showing four very different configurations are instructive, but require some interpretation which is not given in the text. The paper on *L. clavatum* by David and Weber (11) did not add any new facts. Linsbauer's paper (12) is concerned mainly with details of histology. He separates the orthotropic forms from the plagiotropic, and suggests that in orthotropic species the vascular cylinder is comparatively small and the xylems are broken up; the last point is quite in agreement with the writer's conclusions. In the 'Annals of Botany' Mr. L. A. Boodle (14) described two species of *Lycopodium*: *L. volubile*, Frost, which belongs to the dimorphic group and is characterised by a very definite series of parallel bands of xylem and phloem; and *L. salakense*, Treub, in which the xylems and phloems are intermingled, presenting an appearance similar to that described for *L. cernuum* below.

It is convenient to begin the discussion of the morphological structure of the Lycopods by considering first the essential characters of a well-known species, and to proceed from this to a comparative description of other species. Since *Lycopodium clavatum* is generally taken as a type for the genus, the salient features of that species are briefly indicated.

Lycopodium clavatum, Linn.

A feature that characterises most of the temperate species of *Lycopodium* is the plagiotropic habit, and this tendency is well marked in the case of *L. clavatum*. The plant is found creeping along the ground, either on bare slopes or in grass, although its original habitat would probably be in woods or on the outskirts of woods, where by uprooting of the trees the plant would find the necessary condition for the burial of its spores. It is found growing with xerophytic plants, and shows a structure which is well adapted to unfavourable environment. The stem attains a considerable length, often a metre or more; it sends out branches every few centimetres and these show the same plagiotropic tendency. The end of the shoot or branch is often nearly erect, but radial symmetry is not found after the very early so-called seedling stages of the plant, except in the strobilus and in the stalk below the strobilus. In accordance with its dorsiventral structure, the roots, which are produced irregularly at intervals, arise from the lower surface, the branches arise laterally, and the leaves, more particularly those

inserted on the lower side, are curved upwards. The branches form either *short shoots* which produce secondary and sometimes tertiary branches, seldom grow beyond a few centimetres, and develop no roots, or *long shoots* which reproduce the structure of the main axis. The short shoots persist as long as the main axis on which they arise; the long shoots not only help to spread out the original plant, but also serve as a means of propagation when the main stem dies away behind, and each long shoot then becomes an independent plant. The arrangement of the leaves in the adult condition conforms to no recognised system: the leaves do not fall on a spiral, but it is possible to group the leaves into pseudo-whorls, and alternate pseudo-whorls are similar. This arrangement is not always obvious, but due regard must be paid to changes occurring at the insertion of branches. A very constant feature, practically for all Lycopods, is the prolongation of the leaf-base. As an external feature, and one likely to be preserved in casts and impressions, it might prove to be of some importance in the identification of fossil remains, even though many of the Coniferæ are similarly distinguished.

Passing from external features to the internal structure of the stem, the arrangement of the vascular tissues is similar to that which occurs in roots (Pl. **3.** fig. 2 and Pl. **4.** fig. 8); round the periphery there are situated a varying number of protoxylem-groups, and arranged alternately between these a similar number of protophloems. The vascular tissue fills up the centre—whether, as in young stages or in ultimate branches, this consists of solid xylem, or, as in the main stem and larger branches, opposite xylems are joined up—and the general appearance is presented of alternating xylem- and phloem-bands. Around the vascular tissue is situated a pericycle varying generally from two to six layers, narrower opposite the protoxylems and broader opposite the phloems, and this is again surrounded by a 2–3-layered endodermis. The cortex consists of three zones (Pl. **3.** fig. 1), a broad zone, c_1, made up of cells with thick lignified walls, which abut upon the endodermis, a region of thin-walled cells, c_2, encircled by a narrow outer zone, c_3, in which the cells have their walls slightly thickened. The stem is to a very great extent covered by leaf-bases, and in these a loose mesophyll separates the outer zone of cortical cells from the epidermis, but in the stem proper these layers are in contact. The vascular cylinder (Pl. **3.** fig. 2) is somewhat oval and dorsiventrality is obvious in the arrangement of the vascular tissues. The parallel bands of the xylem and phloem lie approximately in a horizontal plane. The xylem-patches situated dorsally and ventrally are either heart-shaped, crescentic, or in the form of an Ɛ. The number of protoxylems is fairly constant throughout the axis, and changes in the number are often associated with the development of a branch. The main axis of well-grown plants contains twelve to sixteen or more protoxylems, the long shoots show about as many as the original axis from which they develop, the short shoots have fewer (six to four). The protoxylems are very obvious, not so the protophloems; it is easy to trace the protophloems near the apex, more especially since they are differentiated early, but in the mature condition they are not so definite; the best differentiation between phloem and pericycle was obtained in sections stained with hæmatoxylin and subsequently washed with water. As stated before, the protophloems and protoxylems alternate, so that the arrangement of these is radial. The disposition of the sieve-tubes is definite, as they form a single row in the centre of the

phloem-strips. Outside the vascular tissue the endodermis is sharply differentiated from the pericycle and stains very similarly to the xylem; the inner cortex, and to a less degree the outer cortex, forms the mechanical tissue, while the median zone serves for water-storage. The cells of the median zone run obliquely, at about an angle of 20° with the vertical as seen in longitudinal section.

The leaf-traces pass down into the stem, entering near the upper insertion of the leaf, bend inwards at a slight angle with the vertical, and shortly connect on to a protoxylem. As there is a single leaf-trace it might be expected that the number of leaves on the stem or branch would furnish an indication of the number of protoxylems, and the leaf-traces would in turn join up to the various protoxylems. This is not found to be the case. Where the number of leaves on the smaller branches is reduced to four or six, then it is usual to find a corresponding number of protoxylems; but where the number of protoxylems increases beyond six, then there is no apparent proportion between the two. Pl. 4. fig. 9 gives the general appearance of a stem with thirteen protoxylems, and in the figure the points at which the successive leaf-traces connect up to the central cylinder are represented, the insertion of the traces having been followed through six nodes. The positions of the protoxylems vary slightly, and their number may change, especially towards the ventral side; but taking the protoxylems, either lateral or dorsal, which remain nearly constant in position, it will be observed that in the six whorls of leaves some protoxylems connect with as many as six leaf-traces, others only with four.

Lycopodium annotinum, Linn.

This species in its structure approaches *L. clavatum* very nearly. The main axis creeps along the ground, producing roots ventrally and branches laterally. The leaves on the main shoots can be resolved into alternating pseudo-whorls, and a common arrangement consists of alternations of six and seven leaves. The roots and branches are fewer in number than in *L. clavatum*, there is not the same marked difference between short and long shoots, and the number of short shoots is smaller. On branches of the second and higher orders the leaves are arranged in alternate whorls of four, and this applies also to branches of the first order which do not form runner-shoots. All parts of the plant, except the strobilar branches, are plagiotropic. The internal structure of the stem, so far as the vascular cylinder (Pl. 4. fig. 10) is concerned, is essentially similar to that of *L. clavatum*. The number of protoxylems in the specimens examined did not exceed twelve and the branches showed six to eight. The cortex is not, however, differentiated into three zones, but practically the whole consists of thick-walled tissue; the leaf-bases are decurrent, so that the stem is almost entirely invested, and, concomitantly with the absence of the aqueous tissue, the epidermis is more heavily cuticularised. The transverse section shows a cavity between the cortical tissue and the mesophyll of the decurrent leaf-base. This cavity extends from the point where the leaf joins the stem and continues through the swollen leaf-base, but does not continue into the free portion of the leaf. The position of the cavity c_1 is indicated in Pl. 4. fig. 11, and between the epidermis and the cavity there are three or four layers of parenchymatous cells (fig. 12). The probable function of the space is for aeration, since it contains no

mucilage and the mesophyll-cells are not well provided with intercellular spaces. A fungus was found permeating the tissues very generally, but there was no reason to suppose that this was regularly present.

L. annotinum shows very distinctly a feature which occurs in many of the Lycopods, *i. e.* the peculiar thickenings and pittings in the walls of the mesophyll-cells, and, generally speaking, striations and pittings are particularly noticeable upon the walls of all cells of Lycopods. The appearance presented in the loose cells of the leaf-base, as seen in the surface view (figs. 12 and 13), is that of oval plates marked with very definite pits. Some of the pits are very large, others much smaller. The whole appearance is that of a magnified sieve-area. In section (fig. 12) it is found that these plates represent thicker portions of the wall, and whereas there are ordinary pits which correspond on the two sides, there are also depressions which occur on one side only, and the larger pits in surface view correspond to these.

LYCOPODIUM COMPLANATUM, Linn.; L. CHAMÆCYPARISSUS, A. Br.; L. ALPINUM, Linn.

It is convenient to take these three forms together. In the first place, Mr. J. G. Baker, in his 'Fern Allies,' unites *L. Chamæcyparissus* as a variety with *L. complanatum*, and these two are included in the small category of Lycopods which have dimorphic leaves, an interesting group suggestive of *Selaginella*. It would not be expected, therefore, that it would be difficult to distinguish *L. alpinum*, which is placed in the *clavatum* section, from the others, as there should be a difference both in the leaves and also in the presence or absence of a stalk to the strobilus. As a matter of fact, while it is an easy matter to distinguish a typical specimen of *alpinum* from a typical specimen of *complanatum*, there has been considerable diversity of opinion between British botanists whether *L. complanatum* has ever been found in this country, and whether these plants are not really specimens of *L. alpinum*. Even those favourably inclined to the inclusion of *L. complanatum* among British plants recognise only one or two localities for it. Mr. Baker was kind enough to supply me with a dried specimen of *L. complanatum* from Germany, and I am also indebted to him for confirming the names of some other specimens of Lycopods which I received unnamed. Interest attaches to *L. Chamæcyparissus* because Sachs's historic figure is referred to that species. A herbarium specimen was obtained which was not suitable for detailed examination.

In several respects the three forms are similar in their external characters. The main stems are distinctly dorsiventral, the leaves on the stem are few in number, but the leaf-bases are well marked. First-order branches are produced only at considerable distances, but branches of a higher order are numerous and follow upon one another quickly, with the result that a tassel of branches may be found arising on branches of the first or second order.

The sections of the stems of *L. complanatum* and *L. Chamæcyparissus* are practically identical (Pl. 4. fig. 14), and differ very little from sections of *L. clavatum*. Probably the most constant difference lies in the cortex, which shows three zones, but the innermost zone is very broad, the median zone is less sharply defined and does not assume the appearance of water-tissue, and the outer zone is reduced to one or two layers. A considerable

amount of variation has been observed in the stems of *L. complanatum*; in some sections the phloem- and xylem-bands are quite parallel and horizontally situated, in others the bands bend outwards towards the ventral side in a V-shape, and at times one or two phloem-patches are isolated by xylem. The vascular structure of *L. alpinum* (Pl. 3. fig. 3 and Pl. 4. fig. 15) is also very variable, and while on the one hand it differs very slightly, if at all, from the irregular arrangement observed in *L. complanatum*, on the other hand there is a great tendency to form isolated phloem-patches or phloem-islands; and in other respects, notably the irregular differentiation of the xylem near the apex, it forms a connecting-link with the second group of Lycopods which is described later and which is characterised by the separation of distinct phloem-islands. In certain longitudinal sections of *L. complanatum* some of the inner cortical cells showed definite but not very obvious spiral thickenings. These are shown in Pl. 4. fig. 16, which indicates the spiral markings and the pits which occur in the cortical cells, also the general appearance of the endodermis, pericycle, and vascular tissues. In view of the difficulty of deciding by means of external morphological features the distinction between *L. complanatum* and *L. alpinum*, an attempt was made to get an anatomical distinction based upon the occurrence of these cells with spiral markings; but they were not distinguishable in some specimens that were definitely assigned to *L. complanatum*, and a better criterion would seem to be the greater tendency to irregularity in the stem of *L. alpinum*. In this connection Mr. G. C. Druce was kind enough to supply me with specimen portions of English plants referred to *L. complanatum*. A very great similarity is apparent, in the case of all three species, in the smaller branches, which generally show a tetrarch structure. The cortical cells have their long diameter approximately horizontal, and the anisophyllous arrangement would seem to justify placing them in the same group.

Lycopodium obscurum, Linn.

This species is placed by Mr. J. G. Baker in the *cernuum* group, which contains erect species with a tree-like habit, and will be known to all botanists who are familiar with the rock-garden at Kew. The anatomical characters of this species are very similar to those of *L. clavatum*, and differ considerably from those of *L. cernuum*, which, as will be seen later, are highly specialised. The erect stem bears a number of roots at the base, and alternating pseudo-whorls of five or six leaves; on the ultimate branches there are alternating whorls of three leaves. The arrangement of the bundles in the smaller branches is tetrarch, so that externally and internally the symmetry is radial; but in the stem the number of protoxylems varies from nine to eleven, and the dorsiventral structure is similar to that noted for *L. clavatum*.

Lycopodium inundatum, Linn.

The habitat of this plant is well known; it occurs in swampy ground close to ponds and lakes. It is the only British form which is not subalpine, and may be found in several districts in the south of England. An important character is the presence of mucilage-cavities, which are described by Hegelmaier. Mr. J. G. Baker makes a small

group of three plants with *L. inundatum*, *Drummondii*, and *alopecuroides*, all of which grow in swampy ground; it would be interesting to know whether they all have mucilage-cavities. In the course of the present investigation no other species was found which contained mucilage-cavities normally. This species furnishes an instance of a plant provided with xerophytic modification which nevertheless grows in water-logged soil. This may be ascribed to the fact that it grows in soil which is rich in humus, and that these modifications are necessary for the plant to obtain and keep the necessary water. Generally the stem keeps close to the ground, produces a considerable number of roots, branches freely when it is growing quickly, and the apices are markedly orthotropic. The strobilus is produced in drier situations, and the structure of this part of the stem is radial.

The best-grown specimens show eight to ten protoxylems (Pl. 4. fig. 19), but frequently they are fewer and in the branches a striking tetrarch structure is obtained (fig. 20). Hegelmaier gives a small figure of the same type as that shown (fig. 27), but his figure does not indicate the protoxylems, which are clearly distinguishable from the metaxylem. The amount of xylem is very considerable compared with the phloem, as there is a central plate of xylem; and, further, the xylem is very broad at the periphery, where it is in juxtaposition to the pericycle, whereas the phloem is particularly narrow. This tetrarch structure is regarded as a reduced condition.

The cells of the cortex are nearly all thin-walled, but there is an appreciable amount of variation in the centrally situated cells in plants taken from different localities. In some, air-spaces are well marked, but in others, where the cells are more compact, the mucilage-cavities are better developed. The mucilage-cavities lie outside the leaf-trace bundle, and run some distance upwards into the leaf and pass down into the stem, but stop at the base of the leaf in the strobilus.

Lycopodium Selago, Linn.; Lycopodium serratum, Thunb.

Both of these species are included in Mr. Baker's first group, of which *L. Selago* is taken as the type. The erect growth of *L. Selago* is well known, but *L. serratum* is sub-erect and may grow much longer than the former; otherwise there are several noticeable points of similarity—*e. g.*, in the indefinite arrangement of the sporangia, the unequal development of sporophylls, the formation of bulbils, and the manner in which the roots grow downwards through the cortex of the stem. The vascular cylinder in *L. Selago* is small (Pl. 4. fig. 21), the number of protoxylems is at the most six or seven, the xylem is flattened out, and, as is generally the case where the protoxylems are few, there is a central xylem-portion, so that opposite phloems are not joined. The middle portion of the cortex consists of large loosely arranged cells, surrounded by a zone of cells with thicker walls. The leaf-bases contain large cavities, as in *L. annotinum*. A striking feature in sections is the presence of roots, of which as many as seven may be found near the base, and these are found to arise quite high up in the plant, even above the point where the stem has branched.

If the stem is growing quite erect the roots do not pass out, but gradually die out, and it is only when the stem is growing obliquely that the roots emerge, and thus at the base

of the plants where the stem is plagiotropic a cluster of roots may be observed, and then above this no further trace of them is evident outside. Besides growing to a greater length than *L. Selago*, *L. serratum* is marked by, comparatively speaking, large leaves, which vary, however, in breadth from 1 to 5 mm. The vascular cylinder may attain considerably greater proportions in *L. serratum* (Pl. 4. fig. 22), and the general configuration of xylem and phloem is more broken; this, as in the case of *L. alpinum*, leads to the formation of isolated phloem-regions and three phloem-islands are shown, but, in these, sieve-tubes are not well developed. Cavities do not occur at the base of the leaves as in *L. Selago*. In the smaller plants, which had been formed from bulbils, two or three roots were found in the cortex, and in old plants as many as nine were observed in some sections. These roots do not grow very far, but from the central cylinder new roots are continually being produced every few centimetres, and the old ones gradually die out. The triarch stage (fig. 23) is taken from the stem of a young plant derived from a bulbil.

Of other species which were very cursorily examined, *L. volubile*, Frost, shows, as Mr. Boodle has already indicated, a definite banded structure. A specimen named *L. uliginosum* is very similar to *L. annotinum*, and shows the same development of cortex, but the cavities in the leaf-base are wanting. *L. tetragonum*, Hook, is similar to *L. Selago*; internal roots are found, and the xylem is cruciate and shows the same broad periphery. *L. reflexum*, Lam., resembles *L. serratum* both in the star-like arrangement of xylem and the isolation of portions of phloems and also in the presence of internal roots.

Lycopodium squarrosum, Frost.

In the abstract of a paper communicated to the British Association by the writer in 1897, which was subsequently published as a note in the 'Annals of Botany' (vol. xii. 1898, p. 558), it was pointed out that there are a number of Lycopods, mostly tropical epiphytes, which differ in several anatomical points from species found in this country and in Europe generally. Of these *L. squarrosum* was taken as a type, and included with it were *L. Dalhousieanum*, *Phlegmaria*, and *nummularifolium*. Externally these plants are characterised by radial symmetry and orthotropic growth. Several features in their internal structure are distinctive: the xylem is not arranged in separate narrow strips, but owing to cross-connections the general configuration is more irregular, and by these cross-connections the phloem in the centre is cut off into isolated portions or islands; the differentiation of the protoxylem does not proceed uniformly from the outer elements to those of the centre as is the case in the *clavatum* type, and the outer portions of some of the xylems, consisting of protoxylems only or together with a few metaxylem-elements, are isolated from the main mass; the sieve-tubes are grouped together in a cluster; also there is little or no mechanical tissue formed in the cortex. Most of these plants have leaves which are large for Lycopods; they show well-marked leaf-bases, but the leaves are whorled in several cases, or very nearly so.

In *L. squarrosum* the leaves are not regular, and alternating pseudo-whorls of six or seven leaves occur; the branches very gradually decrease in size, and dichotomy is the

rule. The stem (Pl. 3. fig. 4 and Pl. 4. fig. 24) shows very distinctly the characters mentioned above; in the centre one or two groups of sieve-tubes with the surrounding parenchyma are isolated as islands, and a similar arrangement of phloem is quite as distinct towards the outside. It will be noticed, too (fig. 24), that there is a break in the connection between the *protoxylem* and the central tissues of metaxylem at five points, and this break occurs in the metaxylem and not where the protoxylem passes into metaxylem. At the position *r.* (Pl. 3. fig. 4), a root is coming off, and it will be seen that the vascular tissue of the root joins on to two protoxylems and one phloem of the stem. In the case of all these epiphytic forms roots may be expected at the base of the stem; during the present investigation they were found only in this species, but that is accounted for by the fact that the material obtained of the other plants of this group did not come from the base. A figure is given in Engler and Prantl's 'Pflanzenfamilien' (i. Teil, 4 Abt. fig. 365, p. 579), in which a root is shown traversing the cortex in the stem of *L. Phlegmaria*.

Lycopodium Dalhousieanum, Spring.

On the oldest part of the stem of *Lycopodium Dalhousieanum* obtainable, which probably represented a branch of the first order, there were seven leaf-bases, which corresponded with an alternating arrangement of three or four leaves, but on a smaller branch there were regularly alternating whorls of three leaves. The vascular cylinder (Pl. 3. fig. 5) is not so definite as in *L. squarrosum*, but in the larger branches phloem-islands are quite distinguishable. A peculiar configuration is one exactly similar to that figured for *L. Phlegmaria* by Pritzel in the 'Pflanzenfamilien' (fig. 365 A, p. 579), in which there are two parallel strands of metaxylem separated by a phloem-band having the sieve-tubes in one line; but outside this the xylem-portions are feebly developed and isolated, and, as the structure of the branch was followed up, cross-connecting portions of the xylem were found, and a very definite phloem-island was formed in the centre in which the sieve-tubes were characteristically grouped. The leaf-bases showed no well-defined mesophyll-cells, and intercellular spaces were not very apparent—both of which facts may be correlated with the well-marked development of the leaves.

Lycopodium Phlegmaria, Linn.; Lycopodium nummularifolium, Blume.

These epiphytic species—the former with a wide distribution through the tropics of the Old World, the latter confined to the Malay Region and the islands to the east—both correspond with the *squarrosum* type.

The material available in the case of each of these species consisted only of branches, and in consequence, as may be seen from the diagram, the sections of *L. Phlegmaria* do not show the phloem-islands clearly delimited throughout, although the isolated portions of the xylem are well marked; but the section of *L. nummularifolium* represented in the diagram (Pl. 4. fig. 25) is distinctly radial and the phloem-islands with the grouped sieve-tubes are quite definite. The radial construction of *L. nummularifolium* is especially noticeable as contrasted with the dorsiventral arrangement of the leaves.

LYCOPODIUM CERNUUM, Linn.

A more complex arrangement of the tissues was found in two specimens, both of which were assigned to *L. cernuum*, and this assumption was confirmed by Mr. J. G. Baker. The one specimen was brought to me from Singapore, and, although the material appeared to include two possible varieties, the general character and internal anatomy were similar throughout. A striking feature was the plagiotropic growth of the stem, which was similar to that of *L. clavatum*; while the strobili furnished the clue to identification as *cernuum*, and the vascular structure was most decidedly radial.

The second specimen was part of the typically erect-growing plant, and agreed with the plant from Singapore in presenting an internal structure which at first sight recalls a *Gleichenia* (Pl. 3. fig. 6 and Pl. 4. fig. 27). The configuration is nearly, if not quite, as peculiar as that of *L. salakense*, Treub, which was described by Mr. Boodle (14). There is a figure of the general structure in Engler and Prantl's 'Pflanzenfamilien' and a general plan is given (Pl. 4. fig. 27), as well as a photographic reproduction of the transverse section of the stem (Pl. 3. fig. 6). It will be seen that the xylems and phloems are entirely intermingled, and the phloem-islands often consist of only a few phloem-elements, or several phloem-groups may be connected together. The protoxylems are very broad. The branches show the same interspersion of the phloem-elements among the xylem, but the proportion of them is considerably less: it was also interesting to find that the root presents a similar appearance to that of the branches. Another feature observed in the stem is the thickened area towards the outside of the cortex; this is very well marked both in the erect and plagiotropic shoots.

In addition to the five species enumerated, *L. dichotomum*, Jacq., *L. linifolium*, Linn., and *L. strictum*, Baker, would appear to conform to the type of *L. squarrosum*. In *L. dichotomum* the configuration of the vascular cylinder is not so definite as might be expected; in the larger stems the cross-connections of the xylem-bands are sufficiently well developed to give rise to isolated patches of phloem, but in the branches the arrangement of parallel bands seems more obvious. Externally, *L. dichotomum* may be distinguished by the very definite areas which are marked by the leaf-bases. The stems of *L. linifolium* and *L. strictum* present a striking similarity to one another in their structure, which corresponds with that of *L. nummularifolium*.

LYCOPODIUM CLAVATUM, L. Seedling Plants.

Having outlined the general extent of variation which occurs in the structure of the vascular cylinder of various species of *Lycopodium*, it becomes a matter of considerable interest to endeavour to ascertain how this structure has been developed. It is entirely owing to the kindness of Dr. Lang that I can bring forward the following evidence, which is based upon the structure of the stem of young plants of *L. clavatum*, as he handed over to me several of the young plants which he obtained during his successful search for the prothalli of that species. Two of the youngest of these are shown in Pl. 4. fig. 28. The youngest plant (A), shown on the left, seems to have retained its radial symmetry. The stem-portion is connected up with the remains of the prothallus, but the first root is wanting, the roots which are shown being adventitious. The lower

portion of the stem bears reduced leaves; these become larger and more numerous till the ordinary condition of the young plant is reached about 3 inches above the prothallus. A plant as young as this seems to show a truly radial facies and is orthotropous. The other plant (B) is probably a good deal older, but not much longer. This differs from the previous plant, since at a certain point the growth has been modified and the structure is suddenly altered. It is possible that this break represents the interruption of growth at the end of the season. This obvious interruption was evident in all but the youngest plants, and in certain cases is clearly shown to occur where a branch arises. It is a possibility that the interruption is due to the transfer of activity from the stem to a branch, when the young plant would present a sympodium and not a monopodium; but this would not be in keeping with the ordinary process of branching which obtains in the species. It will be observed that the principal root in B springs from the stem at a much higher point. The more dorsiventral the shoots the more widely separated are the roots, and in the case of erect stems they are clustered towards the base. The principal feature observed in sections of the young stem is that the vascular bundles present a triarch or tetrarch arrangement (Pl. 5. fig. 29), exactly similar to the structure which may be found in the roots of Gymnosperms or Dicotyledons: the xylem forms a central xylem-plate, so that the four phloem-portions are separated; the pericycle is one- to three-layered and the endodermis shows one or two rows of cells. The thick-walled cortex extends through four rows, and lies against thin-walled tissue which is easily broken down; beyond this a zone, about three cells deep, adjoins the epidermis, which is provided with a well-marked stratified cuticle. The young stem presents, therefore, exactly a similar arrangement of cortex to that which is found in the adult stem. So far as the stem was followed downwards a triarch or tetrarch structure was maintained, but it is not impossible that this might be modified into a diarch structure. A section which was shown to me, labelled "first root," showed what might be regarded as a diarch or tetrarch structure, in which the phloem occupied the central position and separated the two xylem-patches. Such a structure is not uncommon in the adventitious roots, where it is easily explained; but if this obtains in the first root there would be very good reason to look upon it as a late development from the stem, and not as primary. Passing upwards it will be found that, owing to changes which should be considered in reference to the apical meristem, the protoxylem extends along the periphery (Pl. 5. fig. 31), so that it overlaps the phloem, and eventually the far end connects up the central xylem-plate and the phloem becomes isolated (fig. 32). The same process occurs again in the case of the same or another protoxylem, and thus the structure changes from tetrarch to pentarch and then to hexarch (figs. 33 & 34). Similarly, seven, eight, or more protoxylems are differentiated. This process is not only to be observed in the young stem, but, if successive transverse sections of the adult stem are traced up, there is found to be a continual variation in the numbers of the protoxylems of the stem, in many cases associated with the formation of branches. In this way, if a long shoot is being formed, say, upon a stem showing twelve protoxylems, this may drop to ten, or fewer, in the branch which arises, and then by the splitting of a protoxylem eleven are formed, and this repeated leads to the same number as the original stem possessed. It generally

happens that as soon as six or seven protoxylems are formed, either because more phloem is required than can lie in the bays or because sufficient xylem is not formed to keep the central portion intact, two phloems become connected across (fig. 34), and thus the banded structure originates which characterises the *clavatum* group. After the stem has attained a complicated structure, then in the branches, more especially those arising on the short shoots or branches of the second or higher orders generally, owing to the small number of protoxylems which pass off, the structure is reduced, until, in branches which have only six or fewer protoxylems, these are again connected up in the centre by metaxylem and the original triarch or tetrarch structure is attained; this must be regarded as a reduced structure, as in the case of *L. inundatum* (Pl. 4. fig. 20). It is doubtful whether in any seedling the protoxylems have such a broad periphery as shown in this figure. This explanation, it will be observed, does not lend any support to the gamostelic nature of the structure of the vascular cylinder which has been postulated, but is of the nature of a gamodesmy in which the strands which pursue a sinuous course are constantly dividing and reuniting.

Young plants of Lycopodium Selago, Linn., and Lycopodium serratum, Thunb.

Failing any other young plants derived from the prothallus which would furnish comparative evidence, the young plants derived from bulbils were examined. The external morphology of these bulbils has been described by Hegelmaier (5) and Strasburger (8); but these authors do not discuss the vascular structure, except to note that a small bundle, the equivalent of a leaf-trace, passes upwards, and the traces pass off from it. Starting from the base of a young plant, to which the bulbil was attached, the original simple bundle was found. This contains a single xylem-mass, which spreads out and separates into two portions, leaving a phloem-band in the middle (Pl. 5. fig. 35); this diarch stage is the commonest one to be found at the base of the stems of the young plants both of *L. Selago* and *serratum*. It is a structure which occurs fairly commonly also in roots, both where these run through the stem and also in small external roots or rootlets. The protoxylems can generally be distinguished on the outside of the periphery of the xylem in a median position. The phloem-tissue is so homogeneous that it is not possible to say whether it should be regarded as made up of two portions or one. By the extension and subsequent division of one of the two xylems a triarch structure is developed. In this case, generally the xylems are still separated, and this may persist after a tetrarch condition is reached.

In these young plants growing from bulbils the origin of the vascular cylinder is different, in so far that it arises from a leaf-trace, and also since the phloem forms the central portion; but the method of increasing the protoxylems is exactly similar to that described for the seedling of *L. clavatum*.

There seems, then, to be no doubt that the vascular cylinder in the stem of Lycopods has started from a structure which is exactly similar to that found in roots at the present day, and also there is the same formation of thick-walled cortex immediately surrounding it. It may be presumed, as it has always been suggested, that it represents

a very primitive type. Without going so far as to assert that the root-structure has remained unaltered throughout the range of vascular Cryptogams and Phanerogams, it appears that the arrangement which served for Lycopods, both in stem and root, has proved to be suited to roots generally. But as soon as the structure of the vascular cylinder in Lycopods begins to get complex, even in young plants, there is a notable difference, because the disposition of the different elements is constantly changing; even if the protoxylems remain constant in number, the positions are constantly shifting, and the phloem-inlets spread out into bands, or *vice versâ*, and cross-connections between different xylem-bands are formed. It is presumed that the complex structure found in *L. cernuum* and *L. salakense* is the outcome of more irregular development and consequent interspersal of numerous small patches of phloem through the xylem. Examinations of serial sections have been made in order to get exact measurements of the changes which take place. In the stem of *L. clavatum* a U-shaped patch of xylem on the dorsal side was found to remain unchanged throughout a distance of 1·5 cm.; a definite phloem-inlet could be noted for a length of 1·8 cm., but for about 6 mm. it joined into a V curve with another inlet; a small patch, consisting mainly of protoxylems, remained separate for a distance of 1 cm.; other laterally situated portions of the xylem were observed to run for distances of 7 and 8 mm. before they joined up with the central mast of xylem. The stem of *L. squarrosum* lends itself to a determination of this kind. Eight figures (Pl. 5. figs. 37–44) are shown, of which the distance between the first and last was 2·5 cm. The number of protoxylems remains fairly constant, being for the most part sixteen, except in one section, where it has increased to seventeen, but they are constantly changing their positions. A phloem-island (p_1), which is evident in four sections, remains isolated for more than 1 cm. and then joins up to phloem nearer the periphery, and later becomes isolated again; the portion of phloem (p_2), though not isolated, remains tolerably fixed in position and definite through a length of 6 mm. The horseshoe-shaped mass of xylem (x_1), isolated in figs. 39 and 40, can be distinguished in four sections for a distance of 1 cm. The portion of xylem (x_2) remains separated for a similar distance. It is also instructive to observe how the directions of the phloem-areas change. In fig. 37 the phloem is continuous on a line which makes a slight angle with the horizontal, but it is not again renewed in this direction. A peculiar phase of continuity is that shown in fig. 44, where it assumes the shape of a 7. The conclusions to be drawn from these measurements are that the most definite phases may persist from 1–1·5 cm., and others for shorter distances; but it is more apparent that gradual changes are constantly occurring, since the strands seldom run vertically and the different parts are alternately joining up and separating.

Roots.—The structure of the roots has not been critically examined, except in so far as they were found running through the stems of such species as *L. Selago*, *serratum*, and *squarrosum*. It is noticeable, in contrast with the vascular cylinder of the stem, that the bundles of these roots and their orientation remain nearly constant. A very large percentage of the roots are alike, and show the structure which is represented in fig. 36. The vascular system of the root connects up with two xylems and the intervening

phloem of the vascular cylinder of the stem. In most cases the extensions of xylem passing off join up behind as the root-trace separates, with the result that a crescent-shaped mass of xylem is formed with protoxylems at the horns of the crescent, and the bay is occupied with phloem. In fewer cases the xylems do not join up, and then, as in branches, four protoxylems often may be detected. The roots all have a similar orientation, even where several are found, and relatively they change their position but little; the horns of the crescent are always turned outwards. With regard to the length of these roots, which do not emerge from the stem, they have been found to run down for distances varying from 1 cm. to 2·3 cm.

Apex.—Except in the early paper by Nägeli (1), describing the structure in the root-apex of *L. clavatum*, the evidence has been entirely opposed to the existence of a single apical cell in Lycopods, and this decision may be accepted; but Strasburger (7) and, less definitely, Hegelmaier (5) have pointed out that in longitudinal sections of the stem a deeper cell is generally found at the apex, and Strasburger traced out the development of dermatogen and periblem from one outer cell and the development of the phloem from one or two inner cells. The writer has obtained results on the whole very similar to those of Strasburger, but it is not proposed to enter into the discussion of the apex and the differentiation of tissues. The photograph of a narrow apex of the stem of *L. inundatum* shows the divisions very clearly, and has therefore been reproduced (Pl. 3. fig. 7). The deeper cell at the apex has divided into two by a longitudinal division, and the cell below has undergone transverse division; the plerome and periblem can also be demarcated.

Branching.—It is generally stated that in Lycopods the branching of the stem is always monopodial, although it sometimes simulates a dichotomy. The opposite view has also been put forward that the branching is normally a dichotomy, and that monopodial branching is due to the retardation or cessation of growth of one axis. There is, again, the question whether dichotomy is to be limited to those cases where a true apical cell is found and where the two branches arise from the two halves of the apical cell. In Pritzel's account of *Lycopodium* (13) the statement appears that the growing-point ceases to form new tissue and two new lateral growing-points are developed; but the evidence upon which this opinion is based is not given. I am inclined to regard these definitions as too extreme, and in the case where no definite cell exists, then the formation of two similar apices, either traceable in the young condition or based upon the evidence of subsequent similar development of the tissues, may be termed a dichotomy. In *L. complanatum* it is possible to recognise, shortly before the strobili are formed, not only on that part of the plant which will form the strobilus but also on adjacent sterile shoots, branchings which would in this sense be termed dichotomies. Sometimes it is possible to recognise them externally, as is generally the case with *L. complanatum*. In the allied form, *L. alpinum*, they are not so well defined, and it is necessary to cut sections through the tassels of branches, when the forking is generally monopodial, but occasionally a dichotomy is met with. In the creeping Lycopods monopodial branching is found, except in the strobilar region or below it. In epiphytic forms dichotomies are probably the rule.

As a type of monopodial branching, figures of *L. clavatum* are given (Pl. 5. figs. 44–49). In this case the branches arise laterally and the vascular elements broaden out in the vertical plane. Eventually, in several of the xylem-bands towards the side where the branch will come off, the xylem-elements become smaller, and at this point the separation will occur between the stem and branch portions of the vascular elements. It will be observed (fig. 45) that four or five bands of xylem, together with the included phloems, give off connections to the branch: the number varies with the size of the branch. The protoxylems together with metaxylem then separate off, the result being that on the adjacent sides of stem and branch protoxylems are wanting. Very shortly, however (fig. 50), protoxylems become evident at these points. It was found by examining a branch-origin near the apex that after the branch is cut off, about the stage represented in fig. 48, the meristem begins to form protoxylem in addition to the metaxylem, at the point where protoxylems normally occur. There is, therefore, a break in the continuity of the protoxylem.

The connection of the root is practically similar to the connection of a branch, but the roots run off horizontally, while the vascular cylinders of the branches pass off at a small angle.

The connection of the vascular cylinder between the two branches of a dichotomy is formed in a similar way (Pl. 5. figs. 51–54). Before the dichotomy occurs the tissues broaden out in the plane of separation (figs. 51 & 52). Smaller xylem-elements are produced at the centre of the xylem-strands, and at these points separation takes place. In some sections there appeared to be evidence that before the xylems separate pericycle-elements are developed along the centre line, as if the pericycle were pushing into the centre of the cylinder (fig. 35). But in other cases if the first elements formed between the xylem are considered to be pericyclic, then they have for a time no connection with the normal pericyclic ring of cells. Certainly these central elements resemble pericycle rather than phloem, but it is not possible to get a criterion which will distinguish them. Then with regard to the formation of protoxylems at the proximal ends of the separating cylinders, these may begin to be formed without any apparent cause or connection with pre-existing protoxylem-elements, or in some cases a patch of xylem consisting mainly of protoxylem-elements (figs. 51 & 52) is found on the line of division at the periphery on either side; when the xylems have separated, these divide into two and pass inwards, connecting on to the proximal ends of the bands where protoxylems are wanting. Since dichotomies do not occur in most cases, except in the smaller branches, the connection between the branches generally consists of not more than two xylem-bands. The figures represent a dichotomy in *L. complanatum*, a species in which this form of branching is very frequent below the strobili. It will be noticeable that with neither of these forms of branching do gaps occur, except with regard to protoxylems.

The structure of the leaf-trace, as it passes off from the vascular cylinder through the cortex, is indicated in fig. 58. The xylem-elements in the centre are well marked; around them are thin-walled cells having the appearance of pericycle, and outside may be traced a ring of endodermal cells.

Turning to some histological details which have not been satisfactorily established,

it may be stated that, with regard to sieve-tubes, they were found to be very similar to the sieve-tubes of other Pteridophyta. It is almost impossible to detect them in sections mounted in balsam, and for this reason microtome-sections could not generally be used for their examination. Stained with chlor-zinc-iodine, or better with Russow's solution, they showed up very clearly, and resemble perhaps most nearly the sieve-tubes of *Pinus*, having sieve-areas and sieve-plates (figs. 56, 57). With the magnifications used, and without undertaking a long series of investigations with special stains, it does not seem to be possible to determine whether callus is present, although it may be expected. The sieve-tubes are very long and end-walls very rare, but they appear to be transverse or slightly oblique and are quite thin. It will be noted that the structure of the sieve-plates is not correctly represented in the figure given in Janczewski's paper (9).

The endodermal layers of several species, and taken at different points, were examined to see whether the development of the cuticular bands could be followed out. In the species for which a single layer of endodermis has been previously recorded, *L. Selago* and *inundatum*, the early formation of a cuticular thickening on the radial walls, or on radial and external walls simultaneously, was observed, but it does not appear all round the stem at the same time. This unequal development is a distinct feature of *Lycopodium*, both as regards the endodermis and the thickening of the cortex. In other cases, even although the stems were in an early stage of differentiation, cuticularisation appeared to be produced simultaneously on the walls of two layers of cells.

The formation of spiral thickenings in the inner cortical cells of a specimen of *L. complanatum* has been already mentioned, and beyond that no spiral tracheids were found outside the true xylem. The appearance of spiral markings seen in cortical cells in transverse sections was always found to be due to pits.

The proportion of phloem to xylem has been variously estimated: in the stems of such species as *L. clavatum* and *complanatum*, where the phloem-bands are narrow, the proportion of phloem does not appear to be less than in the stem of most Ferns, while the area of the phloem in the section of the stem of *L. alpinum* shown (Pl. 4. fig. 15) is proportionately greater; the stem of *L. squarrosum* shows a maximum amount of phloem, while in the other epiphytic Lycopods examined there is proportionally less with a minimum in the case of *L. cernuum*. In the branches the proportion of phloem decreases. The most obvious explanation is to correlate the amount of phloem with the needs of the plant for storage-accommodation, since the phloem contains so much proteid material, and this would be in keeping with the large amount of phloem found in the stem of the epiphytic species.

Anatomy and Classification.

It is interesting to see how far the results of anatomical investigation are in accord with the classification adopted by systematists. It will be evident that the twenty species mentioned in this paper have been separated into two groups, the second containing a number of epiphytic forms and the first plants with horizontally growing stems, while species with erect stems may be included in either group.

Although this distinction appears to be a physiological one, the basis upon which the groups are delimited is strictly morphological; in the one case, the vascular elements have separated into parallel bands, while in the other differentiation at the meristem leads to the formation of more or less isolated areas. In the subgenus *Selago*, Mr. J. G. Baker identifies two groups under the type species *Selago* and *taxifolium*. The species in each group conform to the same type; but the group of *L. Selago* follows the *clavatum* type, while the group of *taxifolium*, of which most are epiphytic, shows the *squarrosum* type. Practically similar arguments apply to the group of *L. inundatum* and *L. Phlegmaria* which are included in the subgenus *Lepidotis*. The species of *L. squarrosum* and *L. Dalhousieanum* are included with *L. strictum* in the subgenus *Subselago*, which contains species both with erect and pendulous stems. The anatomical characters, as I have indicated, would bring *L. strictum* close to *L. nummularifolium*, and these and *L. Phlegmaria* would be closely allied to *L. squarrosum* and *L. Dalhousieanum*. Finally, I should separate *L. obscurum* very widely from *L. cernuum*, and the affinities of *L. alpinum* seem to me to lie rather with *L. complanatum* than with *L. clavatum*. In making these comparisons, it is not intended to suggest that anatomical structure is to be adopted as a basis of classification, except as an accessory to the more important morphological features which are usually employed by systematists.

It may be mentioned here that, in any hypothesis which endeavours to explain the dorsiventral structure in the creeping stems, the fact must not be overlooked that the banded structure is well marked in the stem of the erect-growing species of *L. obscurum* and the radial structure is maintained in plagiotropic stems of *L. cernuum*.

Before adding a summary of the more important results obtained, I desire to state that this work was originally begun in the Botanical Laboratory at University College, Liverpool, and was continued at the Royal College of Science, London. In addition to the help which I have acknowledged in the body of the paper, I wish to express my thanks to Dr. D. H. Scott, F.R.S., who supplied me with some of the material used in the investigation, and who has always given me most cordially the benefit of his assistance and advice.

Summary.

1. The development of anatomical structure in the vascular system of Lycopods has proceeded along two lines: on the one hand, as the protoxylems increase in number, a series of alternating bands of xylem and phloem is developed; on the other, the phloem is scattered through the mass of xylem in more or less isolated patches, until a structure is produced which simulates that found in a *Gleichenia*. The first form is developed in creeping stems, the second is characteristic of tropical epiphytes, and an extreme development is found in *L. cernuum* and in *L. salakense*.

2. The young stem in the seedling shows a triarch or tetrarch structure, in all essentials similar to the structure generally associated with roots.

3. The complex arrangement found in larger stems is developed from this triarch or tetrarch condition by the division of one of the protoxylems into two strands, and by the separation of a phloem into two portions; subsequently another protoxylem

divides, and this process, together with the splitting of the phloem, is repeated until the number of protoxylems and protophloems reaches the number shown in the large stem. In the early stages there is generally a central xylem-plate, but when the number of protoxylems increases to five or six (*a*) the phloem differentiates in bands reaching from one side to the other, or (*b*) the phloems differentiate as isolated groups which break up the continuity of the xylem in the centre.

4. Subsequently in the branches the number of strands diminishes, and in the ultimate branches the reduced structure is similar to that found shortly after the seedling stage.

5. The disposition of xylem and phloem is constantly altering, not only at the periphery, but also throughout the section generally. The length through which a definite portion of tissue, such as a phloem-island or phloem-inlet, may be traced, varies from about 8 mm. to 1·5 mm.

6. Branching is monopodial or dichotomous. The former is commonly found in creeping species and some erect specimens. The latter occurs frequently in the vegetative shoots of epiphytes and just below the strobilar regions of various species.

7. The sieve-tubes are similar to those found generally in Pteridophyta.

Bibliography.

1. Nägeli, W.—Zeitschrift f. wiss. Botanik, Schleiden und Nägeli, iii., 1846.
2. Cramer, C.—Pflanzenphysiologische Untersuchungen, Nägeli und Cramer, iii., 1855.
3. Nägeli, W.—Beiträge z. wiss. Botanik, iv., 1868.
4. Sachs, J. v.—Lehrbuch der Botanik, 2 Aufl., 1870.
5. Hegelmaier, F.—Zur Morphologie der Gattung *Lycopodium*. Bot. Ztg., 1872.
6. Russow, E.—Vergl. Untersuchungen über die Leitbündelkryptogamen, 1872.
7. Strasburger, E.—Die Coniferen und Gnetaceen, 1872.
8. —— Einige Bemerkungen über Lycopodiaceen, 1873.
9. Janczewski, E. de.—Études comparées sur les tubes cribreux. Mém. d. l. Soc. nation. des Sc. nat. Cherbourg, xxiii., 1881.
10. Strasburger, E.—Bau und Verrichtungen der Leitungsbahnen. Histologische Beiträge, iii., 1891.
11. David, E., et L. Weber.—Études sur les Lycopodiacées en general et en part sur *L. clavatum*. Soc. Syndic. des Pharm. d. l. Côte d'Or, xv., 1896.
12. Linsbauer, L.—Vergleichende Anatomie einiger tropischer *Lycopodium*-Arten. Sitzungsber. der k.-k. Akad. der Wiss. Wien, 1898.
13. Pritzel, E.—Lycopodiaceæ. Engler u. Prantl, Pflanzenfamilien, i. Teil, 4 Abt., 1900, pp. 563–606.
14. Boodle, L. A.—Note on two Species of *Lycopodium*. Annals of Botany, xiv. 1900, p. 315.

EXPLANATION OF THE PLATES.

Plate 3.

Fig. 1. *Lycopodium clavatum.* Transverse section of the stem: c_1, innermost region of cortex; c_2, median zone of cortex; c_3, outer zone of cortex; *l.*, leaf-base. × 20.

2. *Lycopodium clavatum.* Diagrammatic drawing of the vascular cylinder of the stem: *s.t.*, sieve-tubes; *pp.*, protophloem; *px.*, protoxylem; *per.*, pericycle; *e.*, endodermal cells; *c.*, cortex; *l.t.*, leaf-trace. × 100.

3. *Lycopodium alpinum.* Photograph of transverse section of stem. × 20.

4. ,, *squarrosum.* Photograph of transverse section of the stem, showing phloem-islands: *px.*, protoxylem; *s.*, sieve-tubes; *p.i.*, phloem-island; *r.*, root. × 50.

5. *Lycopodium Dalhousieanum.* Photograph of transverse section of the stem: *p.i.*, phloem-island; *px.*, protoxylem. × 50.

6. *Lycopodium cernuum.* Photograph of transverse section of stem: *p.*, peripheral phloem-area; *p.i.*, phloem-island; *px.*, protoxylem. × 50.

7. *Lycopodium inundatum.* Apex of stem. × 300.

Plate 4.

Fig. 8. *Lycopodium clavatum.* Diagram showing general arrangement of xylem and phloem in transverse section of the stem, xylem shaded. × 30.

9. *Lycopodium clavatum.* Diagram showing how leaf-traces join on to vascular cylinder through 6 nodes.

10. *Lycopodium annotinum.* Diagram of the stem. × 30.

11. ,, ,, Longitudinal section of the stem, showing the cavities which occur at the base of the leaves. × 5.

12. *Lycopodium annotinum.* Longitudinal section of leaf-base: *e.*, epidermis; *m.*, loose cells at the base of the leaf; *c.*, cavity. × 200.

13. *Lycopodium annotinum.* Appearance of pits in surface view. × 240.

14. ,, *complanatum.* Diagram of stem. × 30.

15. ,, *alpinum.* ,, ,, × 30.

16. ,, *complanatum.* Longitudinal section of stem, showing general character of cells: *p.*, phloem-parenchyma; *s.*, sieve-tubes; *x.*, xylem; *per.*, pericycle; *e.*, endodermis; *c.*, cortex. Some of the cortical cells have spiral thickenings. × 150.

17. (Deleted.)

18. *Lycopodium obscurum.* Longitudinal section of stem, showing outer cortical cells. × 240.

19. ,, *inundatum.* Diagram of stem. × 40.

20. ,, ,, Transverse section of branch. × 250.

21. ,, *Selago.* Diagram of stem. × 40.

22, 23. ,, *serratum.* Diagram of old and young stems. × 40.

24. ,, *squarrosum.* Diagram of stem. × 40.

25. ,, *nummularifolium.* Diagram of stem. × 40.

26. ,, *Phlegmaria.* ,, ,, × 40.

27. ,, *cernuum.* ,, ,, × 40.

28. ,, *clavatum.* Two seedlings. A, shows remains of prothallus. × 1.

PLATE 5.

Fig. 29 *Lycopodium clavatum.* Seedling. Transverse section of stem: *px.*, protoxylem; *p.*, phloem; *per.*, pericycle; *e.*, endodermis; c_1, c_2, c_3, inner, median, and outer zones of cortex; *e.p.*, epidermis. × 100.

30–34. *Lycopodium clavatum.* Seedling. Diagrams showing how protoxylems increase in number.

35. ,, *serratum.* Transverse section of young plant derived from bulbil: *p.*, phloem; *x.*, xylem; *per.*, pericycle; *e.*, endodermis; *c.*, cortex; *t.c.*, thick-walled cortex which surrounds a root running through the stem. × 250.

36. *Lycopodium Selago.* Transverse section of root running through the stem: *p.*, phloem; *px.*, protoxylem; *per.*, pericycle; *e.*, endodermis; *c.*, thick-walled cortex of stem. × 250.

37–44. *Lycopodium squarrosum.* Diagrams of stem to show changes occurring in the vascular cylinder.

45–50. *Lycopodium clavatum.* Diagrams of stem to show monopodial branching.

51–54. ,, *complanatum.* Diagrams of stem to show dichotomous branching. Phloem-areas indicated by dotted lines.

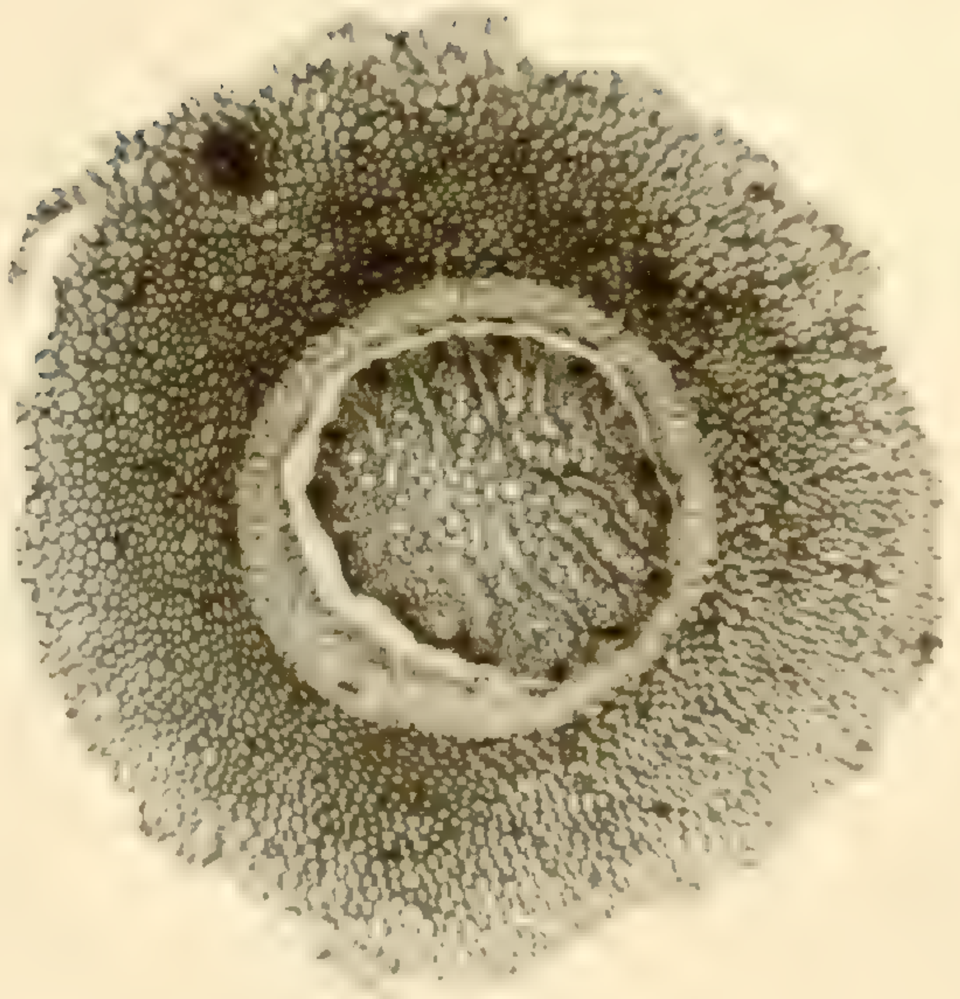
55. *Lycopodium complanatum.* Transverse section of stem at a dichotomy: *x.*, smaller xylem-elements; *px.*, protoxylem; *p.*, phloem. × 80.

56. *Lycopodium cernuum.* Sieve-tube in longitudinal section. × 65.

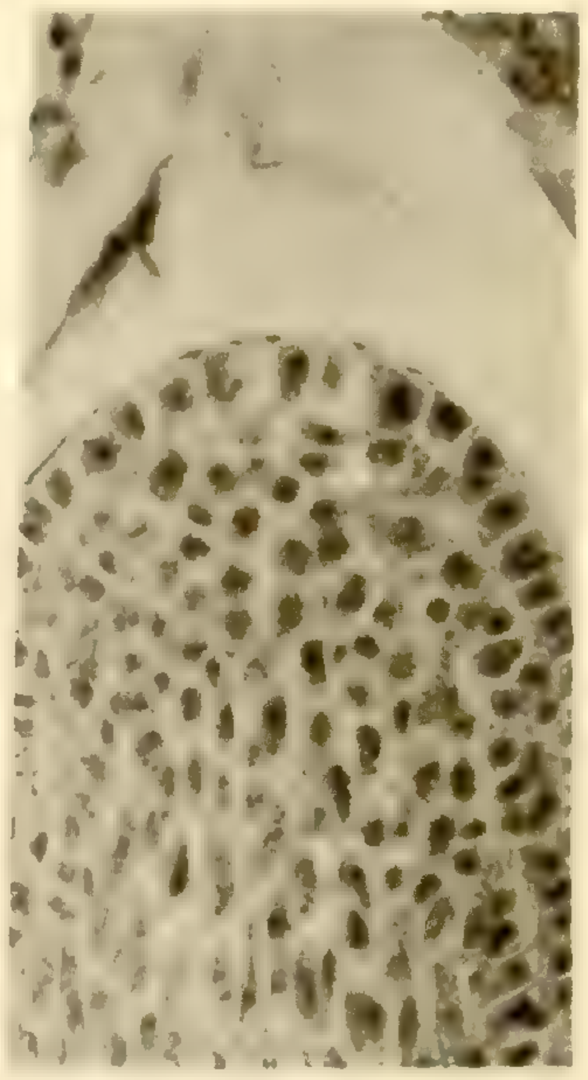
57. ,, ,, ,, ,, ,, × 800.

58. ,, *alpinum.* Transverse section of leaf-trace in cortex: *x.*, xylem; *per.*, pericycle; *c.*, cortex. × 300.

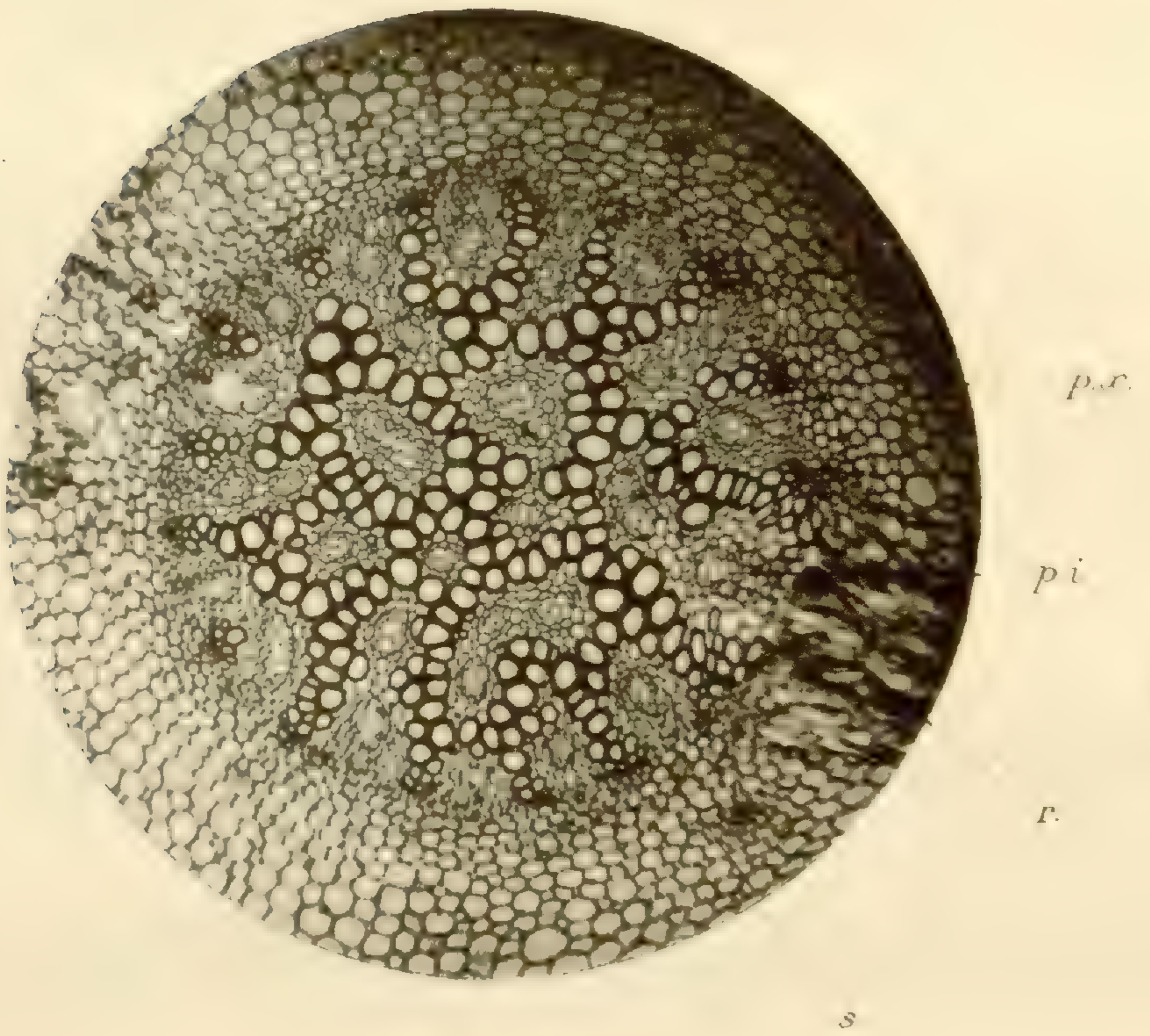
1.



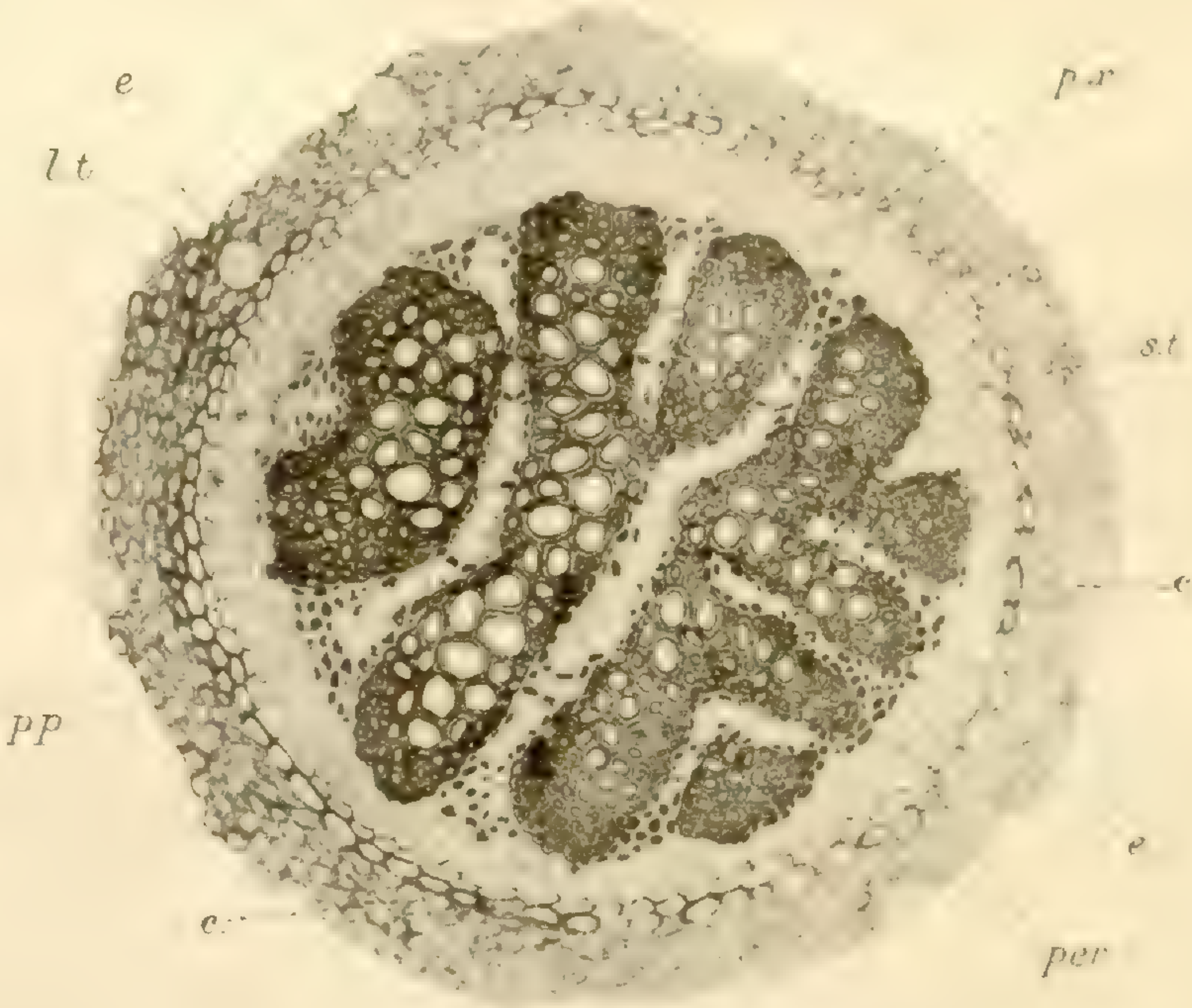
3.



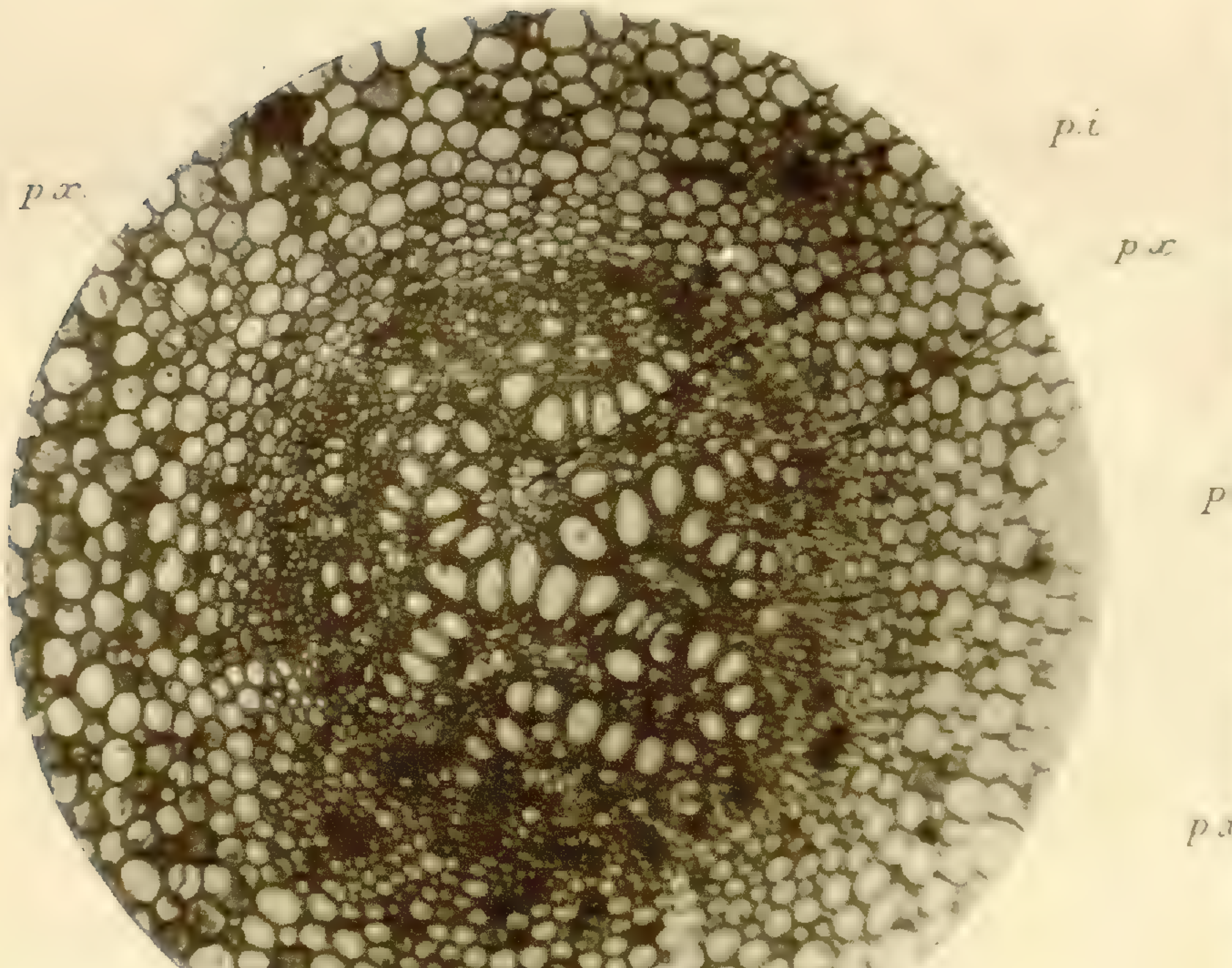
7.



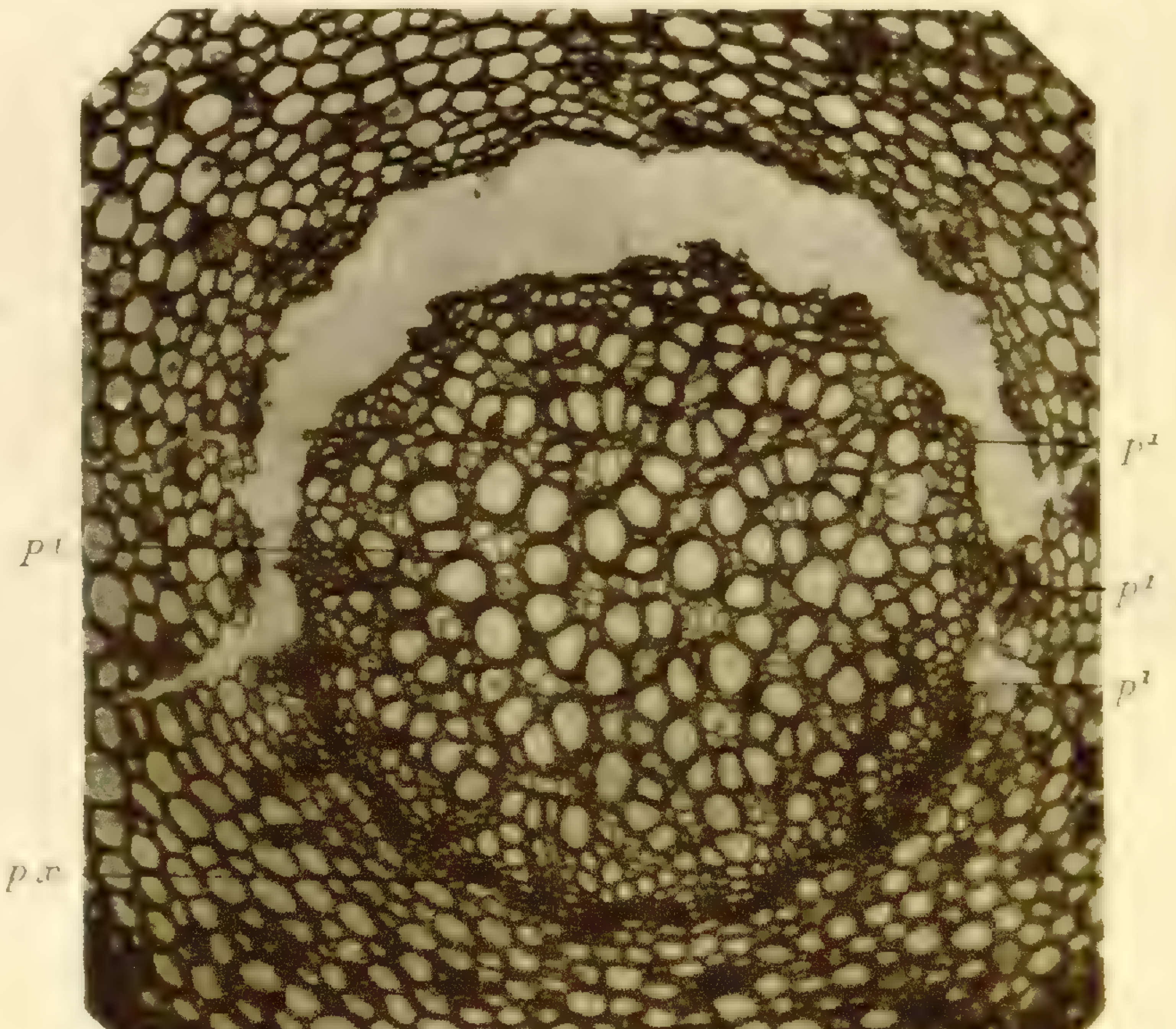
4.



2



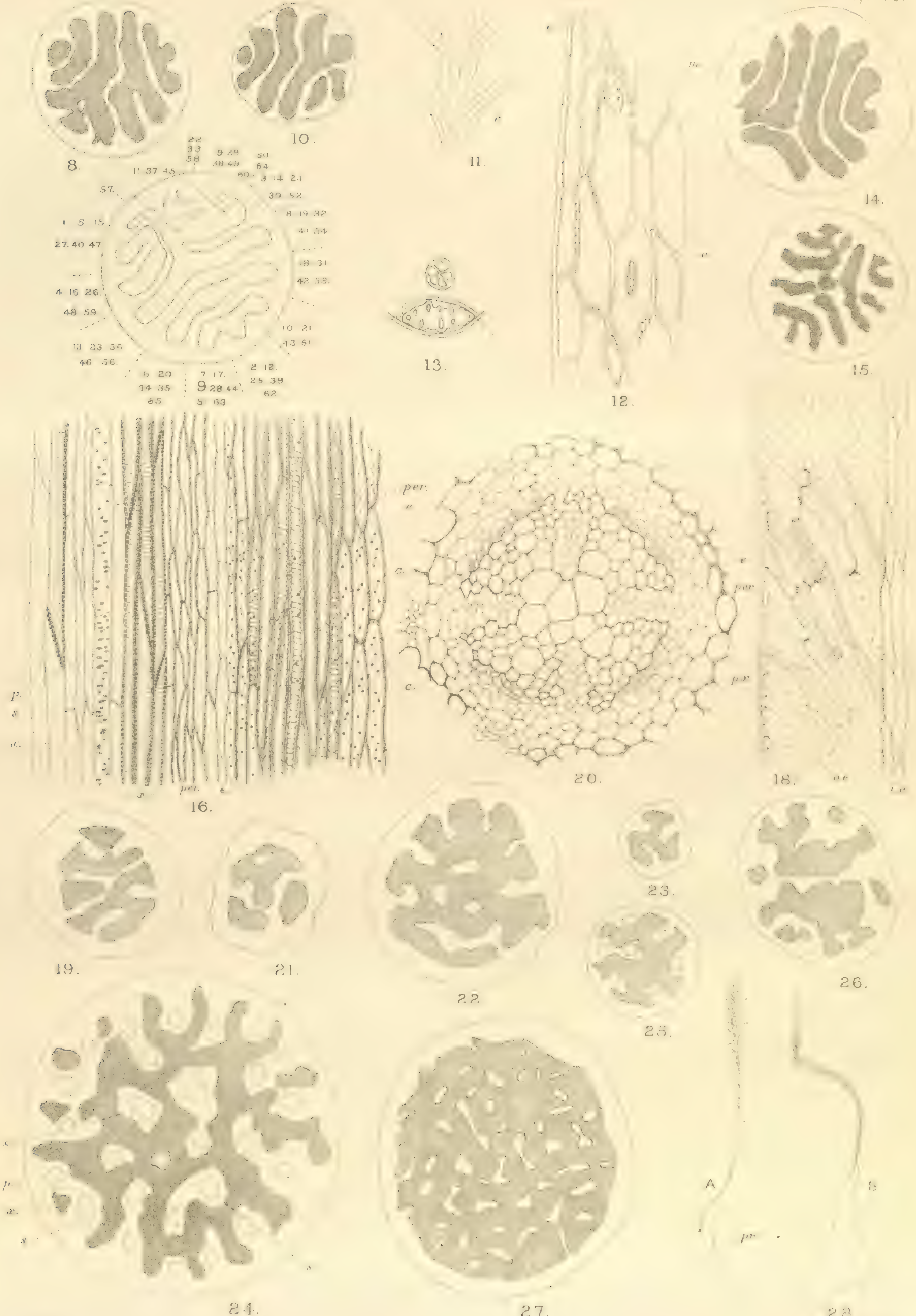
5.



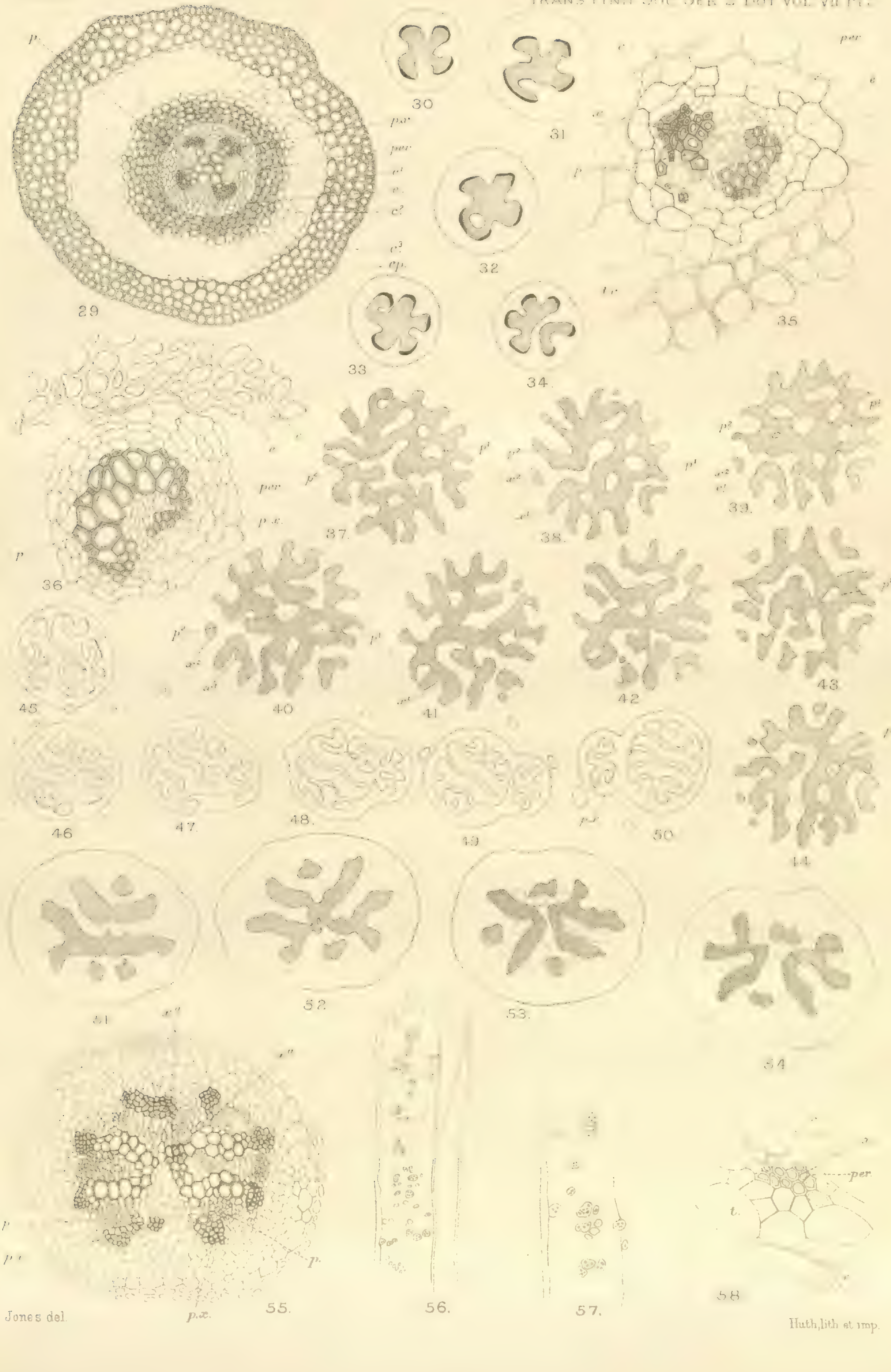
6.

Jones del. et phot.

Huth coll.



Jones del.



Jones del. Huth, lith et imp.

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s*. to the public, and 6*s*. to Fellows; to Vols. 26–30, 4*s*. to the public, and 3*s*. to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

SECOND SERIES.—BOTANY.

Volume.	Part	When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
I.	Part I.	1875	0	8	0	0	6	0
	Part II.	1875	0	16	0	0	12	0
	Part III.	1876	0	12	0	0	9	0
	Part IV.	1876	0	10	0	0	7	6
	Part V.	1878	1	4	0	0	18	0
	Part VI.	1879	1	6	0	0	19	6
	Part VII.	1880	1	4	0	0	18	0
	Part VIII.	1880	1	1	0	0	16	0
	Part IX.	1880	1	0	0	0	15	0
II.	Part I.	1881	0	12	0	0	9	0
	Part II.	1882	0	5	0	0	3	9
	Part III.	1883	0	10	0	0	7	6
	Part IV.	1883	0	3	0	0	2	3
	Part V.	1883	0	3	0	0	2	3
	Part VI.	1884	0	13	6	0	10	0
	Part VII.	1884	0	9	6	0	7	0
	Part VIII.	1884	0	10	0	0	7	6
	Part IX.	1886	0	7	0	0	5	0
	Part X.	1887	0	3	4	0	2	6
	Part XI.	1886	0	6	0	0	4	6
	Part XII.	1886	0	8	0	0	6	0
	Part XIII.	1887	1	7	0	1	0	0
	Part XIV.	1887	0	7	0	0	5	0
	Part XV.	1887	0	10	0	0	7	6
	Part XVI.	1888	0	2	6	0	2	0
III.	Part I.	1888	3	12	0	2	14	0
	Part II.	1891	0	5	0	0	3	9
	Part III.	1891	0	7	0	0	5	0
	Part IV.	1891	0	6	0	0	4	6
	Part V.	1891	0	6	0	0	4	6
	Part VI.	1891	0	3	6	0	2	8
	Part VII.	1892	0	6	0	0	4	6
	Part VIII.	1893	0	6	0	0	4	6
	Part IX.	1893	1	8	0	1	1	0

SECOND SERIES.—BOTANY (*continued*).

Volume.	Part	When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
III.	Part X.	1894	0	10	0	0	7	6
	Part XI.	1894	0	3	4	0	2	6
IV.	Part I.	1894	1	0	0	0	15	0
	Part II.	1894	2	0	0	1	10	0
	Part III.	1895	2	10	0	1	17	6
	Part IV.	1895	0	3	4	0	2	6
V.	Part I.	1895	0	9	0	0	6	9
	Part II.	1895	0	12	0	0	9	0
	Part III.	1896	0	6	0	0	4	6
	Part IV.	1896	1	0	0	0	15	0
	Part V.	1896	0	14	0	0	10	6
	Part VI.	1896	0	4	0	0	3	0
	Part VII.	1897	0	4	0	0	3	0
	Part VIII.	1897	0	6	0	0	4	6
	Part IX.	1899	0	12	0	0	9	0
	Part X.	1899	0	6	0	0	4	6
	Part XI.	1899	0	7	0	0	5	0
	Part XII.	1899	0	12	0	0	9	0
	Part XIII.	1900	0	1	6	0	1	2
	Part XIV.	1900	0	3	0	0	2	3
	Part XV.	1901	0	6	0	0	4	6
VI.	Part I.	1901	1	10	0	1	2	6
	Part II.	1901	0	6	0	0	4	6
	Part III.	1902	0	18	0	0	13	6
	Part IV.	1903	0	8	0	0	6	0
	Part V.	1903	0	8	0	0	6	0
	Part VI.	1903	0	12	0	0	9	0
	Part VII.	1904	0	12	0	0	9	0
	Part VIII.	1904	0	12	0	0	9	0
	Part IX.	1904	0	7	0	0	5	3
	Part X.	1904	0	14	0	0	10	6
	Part XI.	1905	0	4	0	0	3	0
VII.	Part I.	1904	0	5	0	0	3	9
	Part II.	1905	0	6	0	0	4	6

2nd Ser. BOTANY.] [VOL. VII. PART 3.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

CONTRIBUTIONS TO THE EMBRYOLOGY OF THE AMENTIFERÆ.
PART II. CARPINUS BETULUS.

BY

MARGARET BENSON, D.Sc., F.L.S., ELIZABETH SANDAY, B.Sc., AND
EMILY BERRIDGE, B.Sc., F.L.S.

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

April 1906.

III. *Contributions to the Embryology of the* Amentiferæ.—Part II. *Carpinus Betulus.*
By Margaret Benson, *D.Sc., F.L.S., Senior Lecturer in Botany at the Royal Holloway College, Egham*; Elizabeth Sanday, *B.Sc.*; *and* Emily Berridge, *B.Sc., F.L.S.*

(Plate 6.)

Read 16th November, 1905.

Introduction.

Part I. of these contributions was read before the Linnean Society on the 15th of June, 1893, and included the first instalment of results obtained by one of us. The full details relating to *Carpinus* were not given in that paper, nor has any work since been published by other investigators on the embryology of this most interesting genus.

In the spring of 1902, therefore, two of us determined to undertake its investigation, especially as Nawaschin's brilliant discovery of triple fusion in the embryo-sac of *Lilium* suggested the inquiry whether a similar process took place in chalazogamic forms, and if so, in what way it was carried out.

Nawaschin's work on *Betula* (1) and on *Corylus* (2) was published before the discovery of double fertilization. We thus had no work on these genera carried out in the light of this recently obtained knowledge.

Methods.

From an extensive series of sections prepared in 1902–3, combined with a series of confirmatory preparations from material secured in 1904, numbering in all about 600 slides, we have been able to trace the complete history of the embryo-sac and its nuclei from the entrance of the pollen-tube to the first segmentation of the egg. The material was collected chiefly from trees growing in the grounds of the Royal Holloway College.

The first gathering was made at 12 noon on Friday, July 4th, and this was repeated every day, as far as possible at various times, until July 17th.

Both in 1902 and 1904 the fertilization processes seem to have been occurring chiefly between the dates July 6th and July 10th.

Three different solutions were used for fixing:—

1. Absolute alcohol.
2. Flemming's solution (strong formula).
3. ,, ,, (weak formula).

The ovaries were dissected immediately on gathering, the ovary-wall being removed as far as possible, so as fully to expose the ovules to the action of the fixing agent.

The absolute-alcohol material was removed after two days into methylated spirit, where it was left to harden for a week, and then transferred into a mixture of equal parts of absolute alcohol, glycerine, and distilled water for preserving.

The material fixed in weak Flemming's solution was placed, after about two hours, in 5 per cent. chromic acid solution for 16 to 18 hours, then washed in running water for several hours. The material was finally passed up through alcohols of increasing strength into methylated spirit, left there for a week to harden, and transferred eventually into the same preserving mixture as before.

The strong Flemming material was treated in the same way, except that it was left in the fixing reagent for a somewhat shorter period.

To prepare for microtome sectioning, as much extraneous tissue as possible was removed from the ovules, which were then passed through absolute alcohol, bergamot oil, and paraffin of various melting-points, being cut finally in paraffin of 52 degrees melting-point. The sections were mostly cut of the thickness 16 μ.

Two stains were used, viz. Flemming's triple stain and Ehrlich's hæmatoxylin. The former stained well after fixing in Flemming's solution, and the best examples of nuclear fusion were obtained with it, the male gamete being differentiated from the other nuclei by a redder tint; it did not, however, stain the pollen-tubes readily. This was done more successfully with the hæmatoxylin, especially after fixing with absolute alcohol.

We wish to record our obligation to Miss Sargant for most generous preliminary help in selecting the best methods for this piece of work, and for her kind advice and criticism throughout.

Structure and Development of the Embryo-sacs.

The embryo-sacs, while still isodiametric, contain the normal polar groups characteristic of the Angiosperms. They very early develop long cæca, which may penetrate the base of the nucellus, and frequently become much swollen. The antipodals remain lodged in their original position, and thus appear to project into the neck of the cæcum. The upper polar nucleus attaches itself to the one from the antipodal group, and the two descend the cæcum together, generally becoming fused on the way, and forming the large definitive nucleus which is found in the basal part of the fully developed unfertilized sac.

Nawaschin states for *Corylus* that the polar nuclei do not fuse until fertilization has taken place; but this is certainly not the case in *Carpinus*, nor in *Castanea* (Trans. Linn. Soc. ser. 2, Bot. vol. iii. (1894) pl. 67. fig. 21), for, in both, definitive nuclei are found in unpollinated sacs.

To return to *Carpinus*. A considerable number of embryo-sacs, such as have been described above, may develop in one nucellus, and it is not unusual to meet with three cæca, each containing its definitive nucleus, in one longitudinal section. After examining several hundreds of slides showing unfertilized ovules, the uniform character of these embryo-sacs becomes very familiar. In such sacs the egg-cell is always naked, and endosperm never present.

We will now proceed to the processes occurring in the ovule after the pollen-tube has reached the embryo-sac. Of these we have had under investigation about 300 slides. Staining with Ehrlich's hæmatoxylin after fixing with absolute alcohol was found to show up the pollen-tubes with the surprising vividness remarked by Treub in his work on the pollen-tubes in *Casuarina*. Little trace has been found of any resting condition of the pollen-tube, so that no fresh knowledge has been obtained as to its fate during the period immediately subsequent to pollination, though tubes have been found branching freely in the tissue below the styles. The tube occasionally reaches the nucellus before the embryo-sac is mature, and before its full complement of nuclei have been formed. Such a premature arrival gives rise to more or less branching and coiling of the tube around the embryo-sacs (Pl. 6. fig. 2). This also has been observed to occur in older ovules, where the embryo-sacs have for some reason aborted. Belated pollen-tubes also occur running up fresh and strong long after fertilization has been accomplished.

The course of the pollen-tube in the raphe varies considerably. Sometimes it travels in the vascular bundle of the raphe, sometimes quite close to the nucellar wall, and courses intermediate between these two frequently occur.

In the chalazal region the pollen-tube often becomes much swollen and coiled, though not by any means invariably so. There seems to be no doubt that it enters the embryo-sac, as a rule, at the base of the cæcum: occasionally, however, it is found to enter at the side, at some little distance from the base (figs. 7 & 9).

It may branch in the raphe, at the chalaza, or on its way up to the embryo-sac, but most commonly it remains unbranched. It is not by any means the most usual course for the tube to run straight up through the middle of a cæcum to the egg-cell at the micropylar end of the sac. It may follow the wall of the cæcum during the earlier part of its course, and often crosses the sac, but its path invariably brings it into more or less close connection with at least one definitive nucleus, and often with several, as it threads its way among the cæca (fig. 11).

It is exceedingly difficult to distinguish the generative nuclei in the protoplasmic contents of the tube, but in some cases they have been found, both before and after it enters the chalaza. In the section drawn in fig. 4 the two generative nuclei are clearly seen preceded by the vegetative nucleus. The former are separated by an interval of about 10 lengths from each other, while the latter is at some little distance from the tip of the tube, which has not yet reached the egg-cell.

The pollen-tube liberates one of these male gametes, probably the one furthest from the tip, either just after it enters the chalazal end of the cæcum, or as it passes the definitive nucleus. A plug seems frequently to be formed in the tube when this is about to occur (fig. 8, *a*). The gamete appears usually to escape by means of a short branch or spur, though in some cases in which the tube passes close to the definitive nucleus it may simply be emitted through an opening produced by a local softening of the tube-wall. The tube is often considerably swollen at the place where it pierces the embryo-sac wall, and it seems probable that the gamete sometimes escapes at this point (fig. 7).

The spur is very well seen in the preparation from which fig. 6 is taken, and several other cases have been found. A strand of protoplasm, probably marking the path of the generative nucleus, usually connects the spur with the polar nuclei. Several preparations show a generative nucleus in contact with the definitive nucleus, while in one it is in the act of travelling up the cæcum, and lies midway between the spur and the definitive nucleus (Pl. 6. fig. 3, *g.n.*). In this latter case it is slightly crescentic, and stains deeply and uniformly; it resembles those still enclosed in the tube, drawn in fig. 4, but is about twice as large.

One section of a series cut in 1905, stained with the triple stain, contains a very clearly defined generative nucleus. The complete section of the two embryo-sacs of the ovule in which it occurs is represented somewhat diagrammatically in fig. 6. The pollen-tube runs up the side of one sac and throws out a spur just opposite the definitive nucleus. In fig. 6 *a* the latter is seen under higher magnification with the generative nucleus beside it; this is elongated and somewhat flattened, twisted on itself, but not closely coiled. One end rests upon the definitive nucleus, in which the fusion of the polars is quite complete; this appears to take place, however, only just before fertilization, as nuts gathered the previous day almost invariably show the two polars in contact but still quite distinct. Another clear example of a male gamete about to fuse with the recently formed definitive nucleus was found; in this case the male gamete is elongated in shape, but does not appear to be twisted or coiled. A third case was unfortunately somewhat crushed, but it is similar in form to that in fig. 6 *a*.

Several preparations show the definitive and generative nuclei closely associated and more or less fused together; one such case is represented in fig. 5 *a*.

Division of the definitive nucleus follows rapidly after fusion with the generative nucleus, and a day or two later a considerable number of endosperm-nuclei may be observed against the wall of the embryo-sac.

After passing one or, frequently, several definitive nuclei, the pollen-tube makes its way into the upper part of the embryo-sac, and arches over the egg which will eventually be fertilized. In fig. 10, drawn from a preparation showing the fertilization of the egg-cell, only the tip of the pollen-tube appears, running down one side of the egg-apparatus. Between this tip of the tube and the egg-cell, and applied to one side of the latter, is a generative nucleus. It is here seen almost edgeways, and appears to be closely coiled or folded upon itself. A rather ill-defined nucleus is observable within the tip of the pollen-tube. This is probably the vegetative nucleus which has begun to degenerate. A portion of a synergid is also present, but is not figured.

The generative nucleus here seen is of the same size as the two found in contact with the definitive nucleus, being about 14 μ in length, but is considerably larger than those in the tube; an increase in size has often been remarked by workers on other plants after the generative nucleus has left the pollen-tube. After fertilization the egg-cell increases in size and definiteness and soon develops a wall. In this condition it rests for some days while endosperm-formation is actively progressing.

With respect to the question as to whether the tube contains more than the normal number of generative nuclei, we may state that the question is rendered difficult by the

frequent branching of the tube. There is no reason to believe that every branch is supplied by a generative cell; on the contrary, some cases tend to prove that only two are present.

In one case two egg-cells have been fertilized by two branches of the same tube; one branch, presumably representing the spur, having passed by the incompletely fused polars, leaving them unfertilized.

In another case the tube branches high up in the raphe; one branch passes to an egg-cell, the other fertilizes the definitive nucleus by means of a spur, and its tip is abortive. In two other slides, also, from one of which Pl. 6. fig. 11 is taken, the pollen-tube, after passing two or three large and vigorous definitive nuclei, only produces an abortive tip. The probability is that both male gametes have been liberated and have already fused with the adjacent nuclei.

We have thus, we believe, demonstrated that while one male gamete remains in the tube and is carried up to the egg, the other male gamete is usually liberated free into the embryo-sac, though it may sometimes be used by its containing-branch to fertilize the egg-cell of a second embryo-sac. The male gamete resembles in form and behaviour the majority of the vermiform nuclei that have been found in other plants, and is strikingly like that found in *Lilium Martagon*.

The unique method of fertilization which we have found in *Carpinus* has evidently been acquired in correlation with chalazogamy; and this elaborate adaptation to secure the fusion of the generative with the definitive nucleus testifies, as Prof. F. W. Oliver has pointed out, to the importance of the process of triple fusion to the plant.

Comparison with *Casuarina*.

One outcome of this work is to demonstrate the similarity in the embryology of *Carpinus* and *Casuarina*.

Besides the record which Treub * gave for the species *Casuarina suberosa*, *C. Rumphiana*, and *C. glauca* in 1891, Mr. Theodore Frye † has recently given an account of the development and contents of the embryo-sac of *C. stricta*; thus we have a fairly complete history of the processes which lead up to fertilization in that genus. For the sake of comparison we will state the salient points in the embryology of *Casuarina*.

Secondary changes result in the ovary becoming unilocular, with two parietal ovules which are connected with the stylar cylinder or summit of the ovary by a bridge of tissue, as well as by the funicle. The ovule is anatropous and has two integuments. The chalaza is oblique, being directed to the raphe, and thus affords an easier approach for the pollen-tube, which enters the nucellus after descending the raphe.

The sporogenous tissue is very bulky and gives rise to many fully equipped embryo-sacs, and later, in some species, to spirally thickened tracheides. The embryo-sacs are at first isodiametric, and contain in the earlier stages the eight nuclei characteristic of

* Treub, Annales du Jardin Botanique de Buitenzorg, 1891.

† Botanical Gazette, vol. xxxvi., August 1903, pp. 101–113.

Angiospermic embryo-sacs. The polar nuclei meet and fuse. The antipodals perish early, but can occasionally be shown to have formed walls around themselves.

The embryo-sacs, including the fertile ones, produce long basiscopic cæca, along which the pollen-tube may or may not travel. Mr. Frye figures a case of triple fusion which is not quite convincing, owing to the fact that the presence of a pollen-tube is not demonstrated, and it is difficult to believe that it could have escaped notice if it had been present. Although further confirmation seems needed of the observation of triple fusion, there is no reason to doubt that it will be forthcoming. The egg-cell was in no case observed (by Mr. Frye) with a wall, and this is explained by the fact that fertilization had not been carried out, his material being too young for the culminating stages. This brings *Casuarina* into line with the normal case. The clothed oospore rests while endosperm-development proceeds, and the segmentation of the embryo is perfectly normal. We have therefore now a fairly complete story of the embryology of *Casuarina*.

Summary of Characters in which *Carpinus* and *Casuarina* agree.

Both genera consist of arborescent, wind-fertilized species. Both are monœcious, with their flowers closely aggregated in unisexual catkins.

The female flower in both is dimerous, bearing long free stigmas. In *Casuarina* it is borne singly in the axil of a bract, and itself bears two bracteoles. In *Carpinus* the terminal flower of the dichasium is abortive, but flowers are borne in the axils of its two bracteoles, and each itself bears a pair of bracteoles. Thus both genera come under Eichler's type-form for the partial inflorescence for the Amentaceæ*, *Casuarina* differing from *Carpinus* exactly as *Quercus* differs from *Fagus*.

The ovary in both genera is inserted in the radial plane.

The absence of a perianth in the female flower of *Casuarina* is a character common to *Betula* and *Alnus*, and may be correlated with the later development of a wing from the pericarp-wall, which occurs in all three genera.

In *Carpinus* no wing is developed from the pericarp, and hence the perianth persists.

The male flowers in *Casuarina* each consist of a single stamen; but this shows a marked tendency to bifurcate †, a tendency which is still more marked in the numerous stamens of the male flower in *Carpinus*. In neither case can we recognise any perianth, but bracteoles are present in both.

To turn now to the facts of embryology as revealed by the researches of Treub and Frye on *Casuarina*, and by our work on *Carpinus*, as detailed in the former and present part of this communication, we find that in both genera the ovary is originally bilocular and contains two anatropous, bitegumentary ovules ‡.

In both genera secondary fusions take place between the ovule and the placenta to

* Eichler's 'Blüthendiagramme,' pp. 11–49, part 2.

† Fig. 15 B in Engler's 'Pflanzenfamilien,' Teil 3, Abt. 1, fails to indicate this fact.

‡ Demonstrated in *Carpinus* by Miss Ewart, *vide* fig. 314 A, 'Natural History of Plants' (Kerner, ed. by Oliver).

secure the safe passage of the pollen-tube from the stylar region down the raphe, and in both its entry into the nucellus is facilitated by the obliquity of the chalaza.

In both genera (not only in *Casuarina*, as is implied in Engler's 'Syllabus der Pflanzenfamilien,' 1903) a large number of perfect embryo-sacs may be formed, and in *Carpinus* more than one egg-cell may be fertilized.

In the various stages of the development of the sporogenous tissue and of the embryo-sacs, in the early degeneration of the antipodals, the formation of the cæca, the long rest of the egg-cell before segmentation (while the endosperm is rapidly developing), and in the development of tracheides around the megaspores, we have such a consensus of characters as leaves us little to separate the two genera on embryological grounds.

On the whole, the most important characters in which *Casuarina* differs from *Carpinus* are its switch-like habit of growth and its phyllotaxis. These, when combined with some minor differences in floral structure and in embryology, may suffice as grounds for forming a distinct group within the family Betulaceæ of equivalent rank with Coryleæ. This family would then include the three subfamilies Coryleæ, Casuarineæ, and Betuleæ. Such a classification would emphasize the close genetic affinity between *Carpinus* and *Casuarina*, and the term Verticillatæ, as used by Engler in the 'Syllabus' and 'Das Pflanzenreich,' could then be dispensed with altogether.

Bibliography.

1. "Zur Entwickelungsgeschichte der Chalazogamen *Corylus Avellana*, L." Von Sergius Nawaschin, Prof. der Botanik an der Universität Kiew. Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg, 5e série, vol. x. 1899, pp. 375–391, tt. 1, 2.
2. "Ueber die gemeine Birke." Von S. Nawaschin. Mémoires de l'Acad. Imp. des Sciences de St. Pétersbourg, xlii. n. 12 (1894).
3. "Contributions to the Embryology of the Amentiferæ.—Part I." By M. Benson, D.Sc. Transactions of the Linnean Society, ser. 2, Botany, vol. iii. (Feb. 1894) pp. 409–424, pls. 67–72.

EXPLANATION OF PLATE 6.

Fig. 1. Shows the course of the pollen-tube, *p.t.*, in the integument, chalaza, *ch.*, and fully developed embryo-sacs, *e.s.*, of an ovule. *in.*, inner integument; *e.r.*, outer integument; *n.*, nucellus; *e.c.*, egg-cell; *d.n.*, definitive nucleus; *r.*, raphe.

2. Diagram from a series of sections through an immature nucellus. The pollen-tube, *p.t.*, is coiled repeatedly round the outside of the young embryo-sacs, *e.s.*—A curious feature in the ovules of the tree from which this specimen came is that the cæca, *c.*, invariably tended to turn away from the chalaza, *ch.*, and bore through the distal wall of the nucellus, *n.* One ovule from this tree contained two nucelli.

Fig. 3. Basal part of an embryo-sac, showing the polar nuclei, *p.n.*, almost fused, and the generative nucleus, *g.n.*, travelling towards them through the cytoplasm.

4. Upper part of an embryo-sac showing the egg-cell, *e.c.*, and the two synergidæ, *S.* A pollen-tube, *p.t.*, runs up one side of the sac, and abuts on the two polar nuclei, *p.n.* Within the tube can be seen the two generative nuclei, *g.n.*, and the vegetative nucleus, *v.n.*

5. Diagram constructed from a series of sections, showing the course of a pollen-tube, *p.t.*, first in the wall, and then in the lumen of the embryo-sac, *e.s.*; the tube is arrested before reaching the egg-cell.

5*a*. A portion of the same enlarged, showing a late stage of triple fusion, and the strand of protoplasm, *S.*, along which the generative nucleus, *g.n.*, has probably travelled.

6. Two embryo-sacs with egg-cells, *e.c.*, *e.′c.′*, and definitive nuclei, *d.n.*, *d.′n.′* The course of the pollen-tube, is shown, and the liberation of the generative nucleus, *g.n.*, by means of a spur, *s.*

6*a*. The definitive nucleus, *d.n.*, of the previous figure, with the generative nucleus, *g.n.*, about to fuse with it.

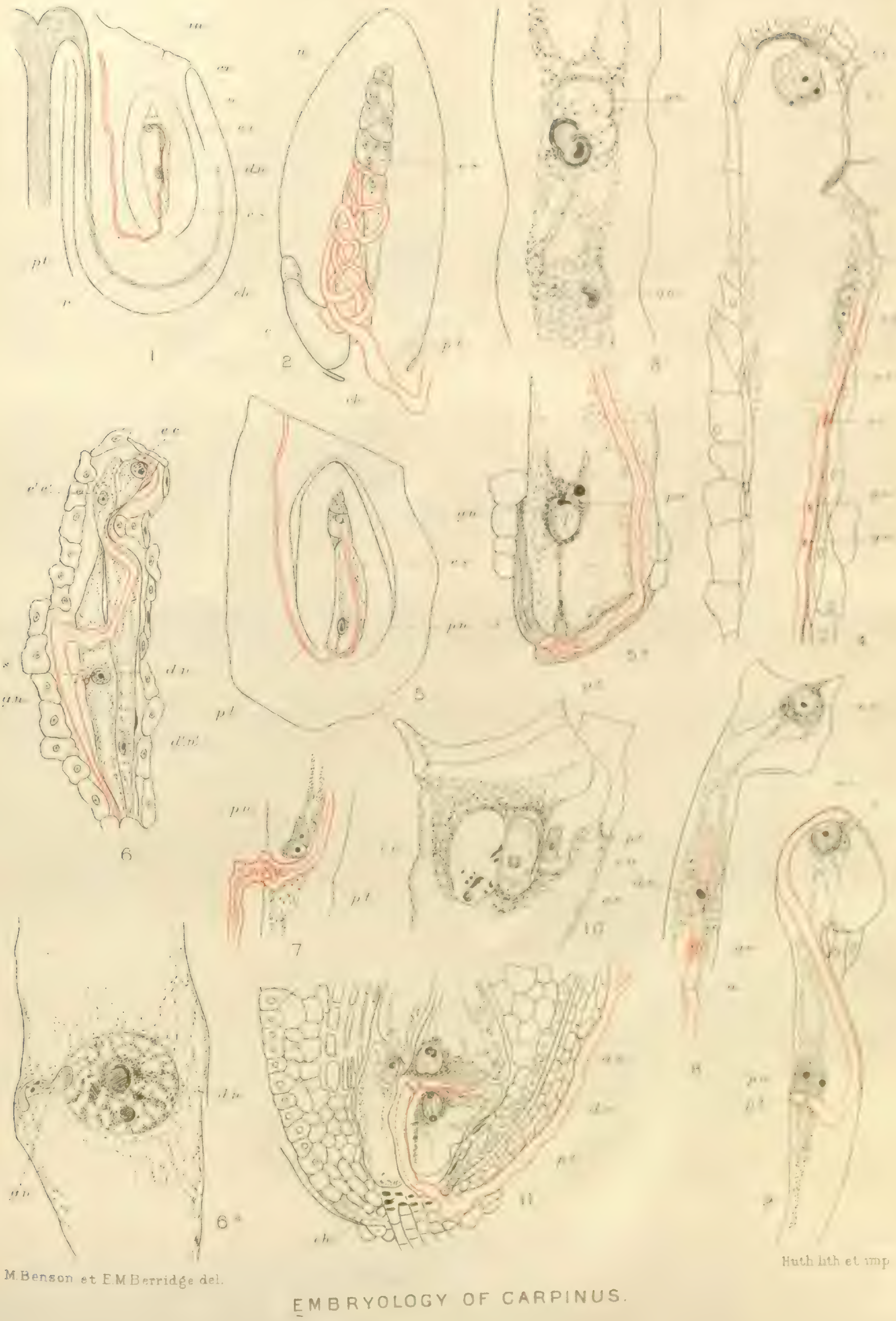
7. A pollen-tube, *p.t.*, entering the cæcum of an embryo-sac at the level of the polar nuclei, *p.n.*

8. The upper part of an embryo-sac, showing the egg-cell, *e.c.*, and the definitive nucleus, *d.n.* The pollen-tube contains two generative nuclei and the vegetative nucleus close together in a group, *g.n.* A plug, *a*, has been formed, probably preparatory to the liberation of one of the gametes.

9. Shows the entry of a pollen-tube, *p.t.*, into an embryo-sac, close to the spot where the polar nuclei, *p.n.*, lie. These include the tube between their elongated lower ends. One synergid, *S.*, is seen by the side of the egg-cell, *e.c.*, which is not yet surrounded by a wall.

10. Fertilization of an egg-cell, *e.c.*, by a coiled generative nucleus, *g.n.* *p.t.*, tip of pollen-tube; *v.n.*, vegetative nucleus.

11. Shows a pollen-tube, *p.t.*, running between the cæca of several embryo-sacs. The tip of the tube is collapsed, and the loss of both generative cells to the neighbouring definitive nuclei, *d.n.*, is suggested. *ch.*, the chalaza.



M. Benson et E. M. Berridge del.

Huth lith et imp.

EMBRYOLOGY OF CARPINUS.

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8s. to the public, and 6s. to Fellows; to Vols. 26–30, 4s. to the public, and 3s. to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

Second Series.—Botany.

Volume.		When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
I.	Part I.	1875.	0	8	0	0	6	0
	Part II.	1875.	0	16	0	0	12	0
	Part III.	1876.	0	12	0	0	9	0
	Part IV.	1876.	0	10	0	0	7	6
	Part V.	1878.	1	4	0	0	18	0
	Part VI.	1879.	1	6	0	0	19	6
	Part VII.	1880.	1	4	0	0	18	0
	Part VIII.	1880.	1	1	0	0	16	0
	Part IX.	1880.	1	0	0	0	15	0
II.	Part I.	1881.	0	12	0	0	9	0
	Part II.	1882.	0	5	0	0	3	9
	Part III.	1883.	0	10	0	0	7	6
	Part IV.	1883.	0	3	0	0	2	3
	Part V.	1883.	0	3	0	0	2	3
	Part VI.	1884.	0	13	6	0	10	0
	Part VII.	1884.	0	9	6	0	7	0
	Part VIII.	1884.	0	10	0	0	7	6
	Part IX.	1886.	0	7	0	0	5	0
	Part X.	1887.	0	3	4	0	2	6
	Part XI.	1886.	0	6	0	0	4	6
	Part XII.	1886.	0	8	0	0	6	0
	Part XIII.	1887.	1	7	0	1	0	0
	Part XIV.	1887.	0	7	0	0	5	0
	Part XV.	1887.	0	10	0	0	7	6
	Part XVI.	1888.	0	2	6	0	2	0
III.	Part I.	1888.	3	12	0	2	14	0
	Part II.	1891.	0	5	0	0	3	6
	Part III.	1891.	0	7	0	0	5	0
	Part IV.	1891.	0	6	0	0	4	6
	Part V.	1891.	0	6	0	0	4	6
	Part VI.	1891.	0	3	6	0	2	6
	Part VII.	1892.	0	6	0	0	4	6
	Part VIII.	1893.	0	6	0	0	4	6
	Part IX.	1893.	1	8	0	1	1	0
	Part X.	1894.	0	10	0	0	7	6
	Part XI.	1894.	0	3	4	0	2	6

Second Series.—Botany (*continued*).

Volume.		When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
IV.	Part I.	1894.	1	0	0	0	15	0
	Part II.	1894.	2	0	0	1	10	0
	Part III.	1895.	2	10	0	1	17	6
	Part IV.	1895.	0	3	4	0	2	6
V.	Part I.	1895.	0	9	0	0	6	9
	Part II.	1895.	0	12	0	0	9	0
	Part III.	1896.	0	6	0	0	4	6
	Part IV.	1896.	1	0	0	0	15	0
	Part V.	1896.	0	14	0	0	10	6
	Part VI.	1896.	0	4	0	0	3	0
	Part VII.	1897.	0	4	0	0	3	0
	Part VIII.	1897.	0	6	0	0	4	6
	Part IX.	1899.	0	12	0	0	9	0
	Part X.	1899.	0	6	0	0	4	6
	Part XI.	1899.	0	7	0	0	5	0
	Part XII.	1899.	0	12	0	0	9	0
	Part XIII.	1900.	0	1	6	0	1	2
	Part XIV.	1900.	0	3	0	0	2	3
	Part XV.	1901.	0	6	0	0	4	6
VI.	Part I.	1901.	1	10	0	1	2	6
	Part II.	1901.	0	6	0	0	4	6
	Part III.	1902.	0	18	0	0	13	6
	Part IV.	1903.	0	8	0	0	6	0
	Part V.	1903.	0	8	0	0	6	0
	Part VI.	1903.	0	12	0	0	9	0
	Part VII.	1904.	0	12	0	0	9	0
	Part VIII.	1904.	0	12	0	0	9	0
	Part IX.	1904.	0	7	0	0	5	3
	Part X.	1904.	0	14	0	0	10	6
	Part XI.	1905.	0	4	0	0	3	0
VII.	Part I.	1904.	0	5	0	0	3	9
	Part II.	1905.	0	6	0	0	4	6
	Part III.	1906.	0	3	0	0	2	3

2nd Ser. BOTANY.] [VOL. VII. PART 4.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

ON SUTCLIFFIA INSIGNIS, A NEW TYPE OF MEDULLOSEÆ FROM THE LOWER COAL-MEASURES.

BY

D. H. SCOTT, M.A., PH.D., F.R.S., SEC.L.S.,

HON. KEEPER OF THE JODRELL LABORATORY, ROYAL BOTANIC GARDENS, KEW.

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

September 1906.

IV. *On* Sutcliffia insignis, *a new Type of Medulloseæ from the Lower Coal-Measures.*

By D. H. Scott, *M.A., Ph.D., F.R.S., Sec.L.S., Hon. Keeper of the Jodrell Laboratory, Royal Botanic Gardens, Kew.*

(Plates 7–10.)

Read 1st March, 1906.

The fossil plant described in the present paper is one among the many interesting petrified specimens obtained from the colliery at Shore-Littleborough, in Lancashire, which, after being closed for some time, has been re-opened within the last three years in the interests of Palæobotany, by the generosity of the owner, Mr. W. H. Sutcliffe, F.G.S.

Among the fossils which this rich locality has yielded up to the present time may be mentioned *Sphenophyllum fertile* (Scott, 1905). *Cyathotrachus altus* (Watson, 1906), *Sigillariopsis sulcata* (Scott, 1904), and a British *Poroxylon* (Scott, 1905, p. 22), besides other species not yet described and many excellent specimens of plants already known.

The new genus, which, as we shall see, it is necessary to found for the fossil stem now to be considered, is named *Sutcliffia*, in honour of the gentleman to whom we owe its discovery. The specific name *insignis* is proposed for this novel and remarkable type. A diagnosis will be given later on in the paper.

Sutcliffia insignis occurs in a nodule from the roof of the workings. The roof-nodules, as a rule, show a peculiar flora distinct from that contained in the ordinary nodules or coal-balls of the coal-seam lying immediately below. As this subject, one of great importance for our knowledge of the distribution of coal-plants and the conditions under which they occurred, is now under investigation by competent hands, the matter need not be pursued further here; it may be mentioned, however, that in several respects the flora of the roof-nodules has a Permian facies, though obviously of Lower Coal-Measure age, an indication that differences due to habitat may sometimes simulate differences dependent on geological horizon.

Petioles, which have proved to belong to *Sutcliffia*, were discovered at Shore a year and a half before the stem itself came to light. One of the first sections I received bears the date April 25th, 1904. The petioles are interesting in themselves; some are of great size, one obviously incomplete transverse section measuring $4\frac{3}{4}$ in. by 3 in. ($12 \times 7{\cdot}5$ cm.). The general appearance of the sections is that of a *Myeloxylon*, but the structure differs conspicuously from that type in the fact that the bundles are concentric, so that a comparison with Seward's *Rachiopteris Williamsoni* (Seward, 1894) at once suggested itself.

All the sections from the Shore material, whether of petioles or stem, were cut by

Mr. James Lomax, by whom the specimens were found. It is an interesting fact, however, that I have lately received sections from a different locality, near Colne, in Lancashire, sent me by Mr. Peter Whalley, which appear to be cut from petioles of the same species. To these specimens, and to the subject of the petiole generally, I shall return after describing the stem.

The first sections of the stem were sent me on October 2nd, 1905, by Mr. Lomax, who then described the plant as "a new *Medullosa*." A few weeks later he sent me a number of other sections, including an extensive longitudinal series. The eleven transverse sections in my own possession proved insufficient to form a satisfactory series, and I found it necessary to ask for the loan of sections which had been sent to other collectors. Prof. F. W. Oliver had, indeed, anticipated my request, and all the other friends to whom I applied at once consented, so that altogether I had at my disposal seventeen transverse sections, all, in fact, that remained in this country. There were four other transverse sections, which had been sent to America or France, and for them I did not ask; but it is not likely that they would have added anything to our knowledge, the series of seventeen having proved sufficient for tracing the course of the vascular strands *. Those whom I have to thank for so kindly lending me sections are, in addition to Prof. F. W. Oliver, F.R.S.†, Miss M. C. Stopes, D.Sc., Mr. R. Kidston, F.R.S., Mr. W. H. Sutcliffe, F.G.S., Mr. W. Watson, and Prof. F. E. Weiss, F.L.S.

Mr. Lomax informs me that the fragment of stem was about 9 inches (23 cm.) long. The sections examined, however, only cover a length of about 6 inches (15 cm.). The comparatively slight change of structure undergone within this distance indicates that the specimen must have formed part of a tall stem, while its transverse dimensions are considerable, amounting to about $12 \times 6{\cdot}5$ cm. in its present condition, in which the form is no doubt somewhat distorted.

The seriation of the transverse sections has been determined, and it will be convenient to give a list of them in their proper order, from below upwards. The evidence on which the upward and downward directions have been determined will appear from the subsequent account of the course of the vascular strands. The sections are indicated by the number or letter which they bear, and, in the case of borrowed sections, by the name of the owner. They are also numbered continuously, from below upwards, with Roman numerals. Sections which I have not seen are not included in this list, but, as far as possible, gaps in the series are noted.

Mr. Watson's section	I.
"X 1".	II.
"X 3".	III.
"X 2".	IV.
Gap, corresponding to longitudinal sections (O. 36, *a*, *b*, *c*) in Collection at University College, London.	
Prof. Oliver's section "O. 35"	V.
Mr. Kidston's section "1033"	VI.

* See, however, the Addendum, p. 65.

† To whom I am also indebted for the loan of three longitudinal sections.

"22"	VII.
"M"	VIII.
Gap.	
Miss Stopes's section	IX.
Gap, corresponding to the 23 longitudinal sections "A–W."	
Prof. Weiss's section	X.
"E"	XI.
"D"	XII.
"C"	XIII.
"B"	XIV.
"A"	XV.
Mr. Sutcliffe's section	XVI.
Small gap, corresponding to Prof. Jackson's transverse section.	
"A 1"	XVII.

An oblique section was cut from the end beyond No. XVII.

The longitudinal sections in the University College Collection were cut parallel to the short diameter of the stele, while those lettered A to W, chiefly in my own collection, were cut in the direction of its long axis.

Mr. Lomax deserves high praise for the admirable manner in which the sections have been cut, so as best to exhibit the structure of the whole specimen.

General Structure.

The structure of the stem as a whole is best shown in Prof. Weiss's transverse section, which is the most complete (Pl. 7. fig. 5). This section is No. X. from below in the series; it was probably cut at a point about two-thirds of the length of the fragment from its basal end.

The peripheral tissues are preserved for a considerable part of the circumference, though destroyed in places, and enough remains to give a fair idea of the general contour of the stem. On the right, above, is a marked protrusion, which must probably be regarded as a leaf-base. It can be traced through the whole series of transverse sections, and though a few additional bundles enter it, it shows no signs of becoming free. It appears, then, that the leaf-bases were decurrent for a long distance, as in *Medullosa anglica* (Scott, 1899, p. 84, pl. 9). There are no means of distinguishing between the cortex of the stem and that of the leaf-bases, and it is probable that we must regard the latter as completely investing the surface. It is unfortunate that no petiole becomes free from the stem within the limits of the specimen. This fact, together with the slowness of the anatomical changes, to be described below, certainly indicates that the stem must have been of considerable height.

The external cortex, wherever it is preserved intact, is of the familiar type of "*Myeloxylon Landriotii*," i. e., it is practically identical with that of a *Medullosa*, such as *M. anglica* (Pl. 9. fig. 16) (Scott, 1899, pl. 5. phot. 3; pl. 12. fig. 14). Tangential sections show that the hypodermal strands of sclerenchyma preserve a straight course, with little or no anastomosis.

The cortex within the hypoderma also has a *Myeloxylon* character, containing a

number of scattered vascular bundles. The most striking feature in their arrangement is the presence of a definite peripheral rank of bundles, adjacent to the hypoderma (Pl. 7. fig. 5; Pl. 9. fig. 16). Towards the interior the bundles are rather sparsely scattered, in smaller numbers than is usual in a *Myeloxylon*. It must, however, be remembered that in *Medullosa anglica* also the leaf-bases attached to the stem are at first poor in bundles compared with the petioles, and only gradually receive their full complement (Scott, 1899, p. 100). In *Sutcliffia* the petiole itself has more numerous vascular strands than the leaf-bases.

In all cases the bundles, as already mentioned, are of concentric structure (see Pl. 9. figs. 14 & 15; Pl. 10. fig. 22). The details of their organisation will be discussed later. Each bundle is surrounded by a ring of small strands of sclerenchyma, and similar strands are also scattered in the ground-tissue. Secretory organs, probably of the nature of gum-canals, though no clear evidence of an epithelium has been obtained, are frequent in the cortex, especially in association with the fibrous strands.

So far the structure described, apart from the concentric bundles, has been of a Medullosean type. The vascular system of the stem, however, is quite different from anything hitherto described in Medulloseæ. The stem contains a single main stele of large size and simple structure. In Prof. Weiss's slide (Pl. 7. fig. 5) its transverse section measures 4·7 cm. in length by 1·8 cm. in maximum breadth, taking the wood only into consideration. The dimensions of the stele undergo little change throughout the specimen, except where vascular strands are given off. There is no pith; the wood extends to the centre, and is in all parts uniformly composed of tracheides interspersed with parenchyma. In this respect the stele of *Sutcliffia* resembles that of *Heterangium*, or a single stele of *Medullosa anglica* *. A vascular cylinder of this type, when only one is present, has been called a *protostele* (Jeffrey, 1902, p. 144).

In *Sutcliffia* the smallest elements, shown by longitudinal sections to be spiral tracheides, lie at the outer edge of the primary wood (Pl. 9. fig. 11; Pl. 10. fig. 18). Hence the structure is *exarch*, as in the genus *Megaloxylon* (Seward, 1899) or in the recent Fern *Lygodium* (Boodle, 1901). The stelar tissue is almost wholly primary; secondary growth had only taken place to a trifling extent, and indications of it are for the most part limited to sections from the lower portion of the specimen (Pl. 8. fig. 10).

The outer region of the wood is very perfectly preserved, but the middle part shows obvious signs of crushing or collapse, for here the elements are more or less flattened in the plane of the long axis (figs. 1–6 & 9). It thus appears that the narrow form of the stele in transverse section is in part due to the collapse of its more central tissues. The change of form, however, does not seem to have been very considerable; in some sections comparatively little sign of collapse is shown, even in the middle part of the stele (Pl. 7. fig. 4). The natural form can never have been

* I am inclined to agree with the view of Mr. Boodle and Prof. Tansley that throughout the Fern-series, at any rate, the structure of the stem is essentially monostelic. I see no reason to suppose that the Medulloseæ are an exception to the rule. Consequently, it is incorrect, from a morphological point of view, to speak of the parts of the vascular system in a dialystelic *Medullosa* as *steles*. I continue to do so, however, in a purely descriptive sense, until a more consistent terminology shall have been established.

cylindrical, but the transverse section may have been more markedly triangular than at present.

The most peculiar feature in the structure of the stem is the presence of large, irregular masses of wood (surrounded by phloem) around the stele, sometimes detached from it, sometimes still in connection (Pl. 7, figs. 1–5; Pl. 8, fig. 6). These masses vary much in size and form, and at first sight give an uncouth appearance to the transverse section, different from anything met with in other stems, though offering some remote analogy with certain anomalous structures in Dicotyledonous lianes *. These vascular masses, subsidiary to the main stele and arising from it, will be called the *meristeles*; the question of their relation to the steles of *Medullosa* will be discussed further on.

The meristele marked α in fig. 5 (Pl. 7) measures $7 \times 4{\cdot}5$ mm.; that at β, on the opposite side of the stele, is much longer, measuring 14×4 mm. † The origin and course of the two meristeles will be traced in the following paragraphs. Other meristeles are seen scattered round the stele, some of comparable dimensions to those already indicated, others smaller, and graduating in size between the former and the ordinary leaf-trace bundles. The smaller groups arise, as we shall see, by the subdivision of the main meristeles. The structure of the meristeles is in all respects similar to that of the stele, and, like the latter, they sometimes show slight indications of secondary thickening.

A curious feature in all the transverse sections (best shown in those from No. IX. upwards) is the occurrence of two conspicuous double rows of vascular bundles, one (*d.r.*) extending from near the left-hand end of the stele (see figs. 5 & 6) to the periphery of the stem, while the other (*d.r.'*) starts just below the stele and likewise runs out towards the surface. The bundles are accompanied by a multitude of fibrous strands. The structure in these regions is well preserved, and there is no possibility of two leaf-bases having been accidentally crushed together, though the series *d.r.'* has probably been pushed in a little towards the stele. It is noticeable that in each double row the bundles of the lower or left-hand series (figs. 5 & 6) are larger than those of the adjacent series. Unfortunately, the remarkable slowness with which structural changes take place in this stem prevents us from seeing what becomes of these bands above or below; I can only suppose that they represent the downward continuation in the stem of the inner surface of a leaf-base which would become detached at a higher level. Fig. 6 (Pl. 7), from the uppermost section of the series, is favourable to this interpretation.

It will be best to postpone histological detail, and to endeavour first to gain a general idea of the vascular system of the plant. For this purpose it is necessary, so far as the material allows, to trace the course of the meristeles and their relation to the foliar bundles.

* Especially with the "lignum circumseptum" of Radlkofer, translated "corded wood," occurring in the Sapindaceous genus *Thinouia* (Solereder, 1899, fig. 53, C–E). This is, of course, a secondary anomaly, and has, therefore, no homology with the structure in *Sutcliffia*.

† In all such measurements the wood only is included, as the limits of the phloem may be difficult or impossible to trace.

Mo. Bot. Garden
1913

Course of the Meristeles.

We will begin by following the course of the meristele designated α, as shown in the series of transverse sections, beginning with the lowest. The sections will be referred to simply by the Roman numerals indicating their position in the series (see table on pp. 46–47).

In the lowest section (I.) the future meristele α is still completely united to the stele, and is represented by a conspicuous promontory about 8 mm. in diameter, and jutting out from the stele to a distance of about 9 mm. In the next two sections there is little change; III. is the first figured (Pl. 7. fig. 1); on the right-hand side of the projection a slight indentation will be observed, and above this, towards the extremity, a small portion at the corner is beginning to detach itself (see the enlarged fig. 7, $\alpha\alpha$, Pl. 8). In IV. this minor meristele is nearly free; it measures $2{\cdot}6 \times 1{\cdot}5$ mm.

Between IV. and V. there is a gap, where longitudinal sections were cut; the interval between sections IV. and V. in the region under consideration was at least 1 cm.*, and it happens that a perceptible change of structure takes place. In V. the minor meristele has departed, the promontory showing a corresponding change of shape; in all probability the former has fused with the end of the long meristele to the right, which here shows an extension towards the left (Pl. 7. fig. 2).

The main projection α appears hooked over towards the right, owing to the deepening of the incision on this side. A very definite group of small tracheides is seen embedded in the interior of the projection about 4·5 mm. from the end; they are arranged in a ring or horseshoe enclosing a little nest of parenchyma, and the smallest elements are only 32 μ in diameter; from these there is a gradual transition to the full-sized tracheides of the surrounding wood, which are very large, ranging from 170 to 320 μ in diameter. The position of this group at first appears to indicate an internal protoxylem, but everywhere else the structure is exarch, so this interpretation is not admissible. The explanation suggested itself that this embedded group might be the downward prolongation of a protoxylem-strand, which at a higher level lies at the periphery of the meristele-xylem, on its inner face. The succeeding sections confirm this view.

In VI. and VII. there is little change, but the incision on the right becomes deeper and approaches the protoxylem-group. In Section VIII. (figs. 3 & 8) the meristele is getting near separation, the deep incision on the right corresponding to one on the opposite side. The embedded protoxylem (Pl. 8. fig. 8, *px.*) has here become nearly peripheral on the inner surface. On the free surface of the meristele there is a marked depression, exaggerated, no doubt, by damage, but indicating a further division, as the next section shows.

Between VIII. and IX. there is an interval, probably representing some of the transverse sections which have not passed through my hands.

In IX. the meristele α has split into two unequal parts, and the larger, measuring $6{\cdot}5 \times 5$ mm., has now separated from the stele, while the smaller strand to the left (under 3 mm. in diameter) is not yet quite free (Pl. 7. fig. 4).

* Judging from the form of the longitudinal sections, the piece cut out was wedge-shaped, so that the transverse sections IV. and V. are not accurately parallel.

There is again a gap between IX. and X. corresponding to the main set of longitudinal sections. The interval was not less than 1·6 cm.

In X. the smaller meristele α' has again divided into two strands, each about 2 mm. in diameter, lying side by side (Pl. 7. fig. 5). All these are now free from the stele. In this and the succeeding sections the large meristele α approaches very near the neighbouring meristele on the right; the intermediate tissue is somewhat obscured by injury, but I have not obtained any evidence of a fusion between these two meristeles.

In the course of the next six sections little change takes place: in the uppermost of the series, however, No. XVII., there are distinct signs of a severance of the large meristele into two parts, along a line nearly parallel to the surface of the stele: the approaching severance is indicated by the presence of well-marked incisions on both sides (see Pl. 8. fig. 6).

This is as far as the series carries us. The derivation of the meristele from the stele and its subdivision are well shown up to a certain point, but not so far as to explain the origin of the actual leaf-trace strands.

The meristele β will now be traced to compare with the former case. This meristele lies on the opposite side of the stele to that just described.

At the bottom of the series, in Sections I. and II., we find a large flat mass of tissue protruding from the stele, to which it is attached near its middle, like the head of a hammer. The total length of the protrusion, in the direction tangential to the stele, is no less than 20 mm., while its breadth varies from 2 to 3 mm. It may have been more prominent in the natural condition than it now appears. There are two or three free strands adjacent to the outgrowth, which not improbably sprang from it at a lower level.

In the first section figured (III.) the left-hand end of the protrusion has just separated, as a distinct strand $3 \times 1{\cdot}5$ mm. in diameter (Pl. 7. fig. 1, $\beta\beta$). This minor meristele may be compared to that given off from α at an early stage (see above, p. 50), but its fate appears to be different: in the present case it moves off rather rapidly to the left, but cannot be identified with certainty beyond Section IX. (Pl. 7. fig. 4); probably it breaks up into leaf-trace bundles, but they cannot be definitely distinguished from neighbouring strands.

Returning to the main meristele β, we find that Section V. shows important changes (Pl. 7. fig. 2). The whole protrusion has here separated from the stele, except perhaps for a slight connection remaining to the left of the centre. At the same time the mass is just splitting into two unequal parts, the left-hand meristele (β') being $4{\cdot}5 \times 3$ mm., and the right-hand (β) $11 \times 3{\cdot}5$ mm. in diameter. At Section VII. the separation of the two meristeles from the stele and from each other is certainly complete, so that β becomes free at a lower level than α. In VIII. the separation is very obvious (see fig. 3).

In Section IX. (beyond a gap) considerable changes have taken place. The smaller meristele, β', has here moved to a distance of a millimetre or more from the main part, β; the interesting point, however, is that the latter is fusing, on the right, with another meristele, which up to this point has been quite independent. On comparing fig. 3 (from Section VIII.) with fig. 4 (from Section IX.) this fusion will be evident. In

order to show the fact more plainly the large-scale fig. 9 (Pl. 8) has been added, from which it will be seen that, in spite of some local damage, the continuity of the tissues is beyond doubt. This is the first definite case met with of a fusion between two independent meristeles, though it will be remembered that there was reason to suspect a fusion, on a smaller scale, in connection with meristele α (see p. 50).

The meristele with which β fuses may be called γ, and the product of their fusion B. It is of interest to trace the previous history of γ as far as possible.

It is already present in the lowest section as an independent strand lying to the right of β; and is practically unaltered in Section III., the first figured (fig. 1). From its dimensions ($5 \cdot 5 \times 3 \cdot 5$ mm.) and form it is improbable that it arose from β, and more likely that it had a common origin with the two meristeles immediately above (fig. 1), which, at the base of the series, form a single mass.

In Section V. (fig. 2) a strand begins to detach itself from γ at the top right-hand corner; this becomes free in the succeeding sections, and is seen in fig. 4 (from Section IX.) at γ'; this is a large strand, with a mean diameter of about 2 mm. A smaller strand (γ'') is then detached from the lower end of γ (fig. 3, from Section VIII., and figs. 4 & 9, from Section IX.), and the remaining mass fuses, as already stated, with the meristele β.

In Section X. (which, as will be remembered, is separated by a considerable interval from IX.) the fused meristele B is neatly rounded off, and evidently a good deal of tissue has been detached from the end corresponding to γ. A large strand (B′), $3 \times 2 \cdot 5$ mm. in diameter, adjacent to this end of B, clearly represents a part of this detached mass, and it is probable that the strand exterior to this, and possibly one or two smaller neighbouring bundles, shared the same origin.

In Section XIV. B′ has cut off another small bundle, and in XVII. the uppermost section of the series, the meristele B appears to be giving off a fresh strand from the same end as before (Pl. 8. fig. 6) *.

Only one more point remains to be mentioned in connection with this part of the bundle-system. The smaller meristele β', which separated from β before its fusion with γ (see above, p. 51), moves off rapidly to the left, comes into contact with the stele, and gradually becomes embedded in the wood of the latter (figs. 2–6). If this were a genuine case of the re-fusion of a meristele with the stele, it would be of much interest, but careful examination has convinced me that the appearance of fusion is delusive, and that the meristele has merely been pressed mechanically into the substance of the stele, owing to a crushing-in of the cortical tissues in this region.

If we endeavour to sum up the main points in the course of the meristeles as shown in the two examples traced, we find that a considerable mass of tissue gradually separates from the stele, and successively subdivides into strands of very unequal dimensions. The giving-off of small strands may begin before the main meristele has become free. It is not proved that the whole mass is ever completely used up in the formation of the smaller strands. The most interesting point is the occurrence of fusion

* The actual separation here is due to injury, but there are indications of a natural incision having appeared.

between meristeles probably of quite distinct origin, as shown clearly in the second case (B) and indicated in α also. The occurrence of fusion suggests that the meristeles may have formed a kind of network round the stele, new meristeles springing at intervals from the latter, to compensate for those parts of the reticulum which were used up in the formation of leaf-trace strands.

The origin of the latter is not completely cleared up by the two cases investigated, for we have not been able to trace the strands given off from the meristeles to the stage where they become typical foliar bundles. Probably the length of stem covered by the 17 transverse sections is not enough for this.

Hence it is desirable to begin with a meristele already free from the stele, and trace it through the upper part of its course.

As our example, we may choose a small meristele (*m.*) lying just off the promontory we have called α (figs. 1 & 7), with which, however, it probably had no connection. At the bottom of the series this meristele (itself no doubt the product of the previous subdivision of some larger mass) measures about 3×2 mm. It shows distinct traces of secondary wood, absent only on the side towards the stele. There is a small bundle to the left, which has probably been derived at a lower level from this meristele. Up to Section IV. the meristele remains unchanged except for some rearrangement of its elements. Fig. 7 (Pl. 8) shows it as it appears in Section III. In Section V. the meristele has broken up into three bundles (*m.b.*), each a little over 1 mm. in diameter (Pl. 7. fig. 2) and of similar structure to that represented in fig. 14 (Pl. 9). The three bundles are shown at a somewhat higher level (Section VIII.) in fig. 8 (Pl. 8); here the innermost of the three remains near its original position, while the other two, accompanied by the one that became free previously, have moved towards the outside. In succeeding sections these three bundles travel further and take their places in the peripheral rank of leaf-traces. The inner bundle remains behind, and no doubt simply forms one of the internal strands of the cortex or leaf-base (Pl. 7. fig. 5, Section X.).

This completes the history of the course of the bundles in the stem; the meristele from which we started is of similar dimensions to some of those of which we have traced the origin in the previous series α and β. Hence if we combine our new data with those derived from one or other of these series, we have the complete course of the vascular strands, beginning with the first separation of the main meristeles from the stele, proceeding through their various subdivisions, and ending with definitive foliar bundles belonging to the leaf-base.

It may be mentioned that the bundles in the leaf-bases frequently fuse and branch. An example of a fusion between two of these strands is shown in Pl. 7. fig. 5, at *r.b.*

The question remains: Are we to regard the whole as a leaf-trace system, or should the main meristeles rather be considered as a part of the stelar system? In other words, are the meristeles to be compared with the large leaf-traces given off from the steles in *Medullosa anglica*, or with the steles themselves?

In that plant the leaf-trace, where it first becomes free from the stele, is a large, probably concentric, strand, with primary wood from ·5 mm. to 1 mm. in diameter, the structure

bearing much resemblance to that of the stele itself, on a small scale *. There is, so far, a marked agreement with the meristele of *Sutcliffia*. In the *Medullosa*, however, the main leaf-traces break up completely into the collateral bundles which enter the bases of the leaves; there is no evidence of fusion with neighbouring strands, nor any indication that a part of the strand remained behind in the stem after the foliar bundles were given off; the strands, in fact, constitute a leaf-trace system, and nothing more. They cannot, therefore, be directly compared to the meristeles of *Sutcliffia*.

On the other hand, the meristeles of the latter genus are evidently very different from the steles of *Medullosa anglica*, which are all of equal value, and constitute collectively the whole vascular system proper to the stem. The meristeles of *Sutcliffia* can at most be regarded as subsidiary steles.

The complex Permian Medulloseæ do not seem to afford any satisfactory analogies, for in them the principal steles are peripheral; the "star-rings" might be called subsidiary steles, but their position is central, and they have no direct relation to the leaf-traces.

Sutcliffia is, in fact, an isolated type at present, and the interpretation of its structure correspondingly difficult. It is possible that we have in this genus the first beginning of dialystelic structure. The Medulloseæ generally are characterized by the enormous development of their leaves, demanding an exceedingly complex and extensive vascular supply, which the simple protostele is evidently ill-adapted to provide. In all members of the family hitherto known, the megaphyllous requirements are met by the breaking up of the stele into a more or less elaborate system of distinct but anastomosing cylinders, some or all of which, as the case may be, are concerned in the provision of leaf-traces. In *Sutcliffia* we have the unique case of the protostele persisting as the main vascular axis of the stem, while giving off a peripheral system of subsidiary steles or meristeles, which form the points of departure for the actual leaf-traces. This seems the simplest explanation of the facts, and, if accepted, it probably involves our regarding *Sutcliffia* as the most primitive, anatomically, of the Medulloseæ. It might, no doubt, be possible to interpret the structure of *Sutcliffia* on an hypothesis of reduction; but considering the large dimensions of the plant and its high organization, such a suggestion seems to have no adequate basis. The structure of the petiole, on the other hand, fits in well with the idea of a relatively primitive position. There is one point, however, which suggests caution in our conclusions. Some of the detached petioles are very much larger than the leaf-bases attached to the one specimen of the stem which we possess. Hence it is evident that this specimen was not a full-sized one. It may have belonged to a young plant, or to the basal part of an older one, and it is quite possible that the larger stems may have had a more complex structure, just as we find in so many Ferns at the present day. *Sutcliffia*, it is true, was not a Fern, and it may be that its vascular system acquired its mature form merely by secondary growth, only just beginning in our specimen. The possibility, however, of an increasing complexity of the primary structure in the later-formed regions of the stem must not be lost sight of.

* Scott, 1899, pp. 92, 93; pl. 6. phots. 6–9; pl. 11. fig. 10.

It is unfortunate that neither the position of the meristeles nor the arrangement of the leaf-bases themselves gives any certain clue to the phyllotaxis. The most definite leaf-base is that which occupies the lower left-hand portion of the transverse sections, in the position in which they are figured. At the top of the series, in Section XVII. (Pl. 8. fig. 6), the individuality of this leaf-base is well-marked, and it appears to have been approaching its separation from the stem *. No other appendage shows any definite demarcation at this level, so that we may assume that the phyllotaxis was spiral and not verticillate. The appearances are not inconsistent with a $\frac{2}{5}$ arrangement, such as exists in *Medullosa anglica*, but no positive conclusion can be drawn.

Histology.

1. *Structure of the Wood.*—The wood of the stele has essentially the same structure—apart from the position of the protoxylem—as in *Medullosa anglica*, and requires no detailed description. The primary tracheides, which, as already mentioned, are of exceptionally large size, sometimes reaching 350 μ in diam., bear the multiseriate bordered pits which are so common a character in Palæozoic woods. In the stele itself the details of structure are not usually well-preserved, owing perhaps to too slow penetration by the petrifying substance, but in the more external bundles the preservation is all that could be desired, as shown in Pl. 10. fig. 18. The exarch character of the protostele of *Sutcliffia* at once suggested a comparison with the *Megaloxylon* of Seward; it is therefore of importance to point out that throughout the stele in *Sutcliffia* the tracheides are of the ordinary elongated form (Pl. 9. fig. 12), and there is no trace of the short and broad xylem-elements, adapted probably for water storage, which are so characteristic a feature in Mr. Seward's fossil (Seward, 1899).

The comparatively thin-walled wood-parenchyma forms a continuous network among the tracheides, separating them into small groups or sometimes single elements (Pl. 9. fig. 11). The parenchymatous cells are transversely elongated in a direction parallel to the walls of the adjacent tracheides, so that a longitudinal section sometimes shows a structure remotely suggestive of medullary rays (fig. 13). Among the ordinary cells of the xylem-parenchyma there are numerous scattered elements with dark contents, perhaps of a secretory nature; these sacs may resemble the neighbouring cells, or may be larger in one or other dimension.

The position of the protoxylem, as already pointed out, is, generally speaking, external. An example of this is given in Pl. 8. fig. 10, where a group of tracheides is shown with the smallest elements towards the outside (*px.*). Another illustration is given in Pl. 9. fig. 11; here the right-hand group becomes smaller-celled towards the exterior, and terminates in one or two crushed elements, clearly the collapsed protoxylem. On the left the most external element is rather larger than some of those to the inside of it—an occasional irregularity, which appears too trifling to justify us in applying the

* The fact that the limit of this leaf-base lies so near the stele is no doubt due to the intervening cortical tissue being lost.

word "mesarch" to such cases. It is very common for the prominent protoxylem-groups to run in pairs as shown in this figure.

Longitudinal sections, where they are well enough preserved, show the small spiral elements at the periphery, succeeded towards the interior by denser spiral and scalariform tracheides, and finally the pitted elements characteristic of the bulk of the wood. It has not been thought necessary to give a figure of this from the stele, as the structure is precisely the same as that shown in Pl. 10. fig. 18 from a large leaf-trace bundle. Throughout the plant the structure of the vascular strands of all orders is exarch, apart from the trivial irregularities already noted, which need not be regarded as real exceptions to the rule.

We will now pass on to the secondary tissues, which are only represented to a very small extent in our specimen. An example is shown in fig. 10 (Pl. 8) from a photograph taken from one of the lower sections (No. IV. from the bottom). The thin-walled cambial zone, passing over towards the outside into secondary phloem, is well preserved. A few secondary tracheides have been derived from it on the inner side, but not more than three or four in any radial row. In other parts cambium alone is found, and no secondary wood had begun to form. The secondary tracheides are small compared with those of the primary wood, and do not exceed 120 μ in their maximum diameter, which is usually tangential. This character is shared by the secondary wood of *Heterangium* * and *Megaloxylon* †.

In the lower part of the specimen the formation of secondary wood can be traced all round the stele and extends to the meristeles, but, as fig. 7 shows, its amount is altogether insignificant as compared with that of the primary xylem. As we follow the structure in the upward direction, through the successive transverse sections, we find the secondary xylem still less developed, and in some places, though the preservation is good enough to show the soft tissues well, even the cambium does not appear to have formed. Our specimen thus represents a plant at the stage when secondary thickening was just beginning, and the structure, at a more advanced age, may have assumed a very different character. On the other hand, it is possible that, as seems to have been the case in *Heterangium Grievii*, the secondary tissues may never have attained any very great development.

2. *Structure of the Phloem.*—We will begin with the phloem of the stele and meristeles, which differs somewhat from that of the smaller vascular bundles.

The soft tissues surrounding the wood are best preserved in the lower sections of the series. In this region a broad band of delicate tissue is often preserved, just outside the wood, contrasting sharply with the coarser parenchyma of the cortex (see fig. 7, from Section III.). A portion of this tissue is shown, in transverse section, in Pl. 10. fig. 19. It is made up, for the most part, of a thin-walled parenchymatous tissue, the cells measuring about $80 \times 50\ \mu$, the larger diameter being usually tangential to the adjacent wood. Among the parenchyma are numerous small sacs with dark contents, as well as

* Williamson and Scott, 1895, p. 751, pl. 26. fig. 24, pl. 28. fig. 32.

† Seward, 1899, p. 160, pl. vii. fig. 8.

the secretory canals, which are particularly well shown in this tissue. Near the wood, especially, smaller elements about 20 μ in diameter are met with, usually in groups. The longitudinal section (fig. 20) shows that the parenchymatous cells and secretory sacs are quite short, while the small elements are greatly elongated, and form, for the most part, well-defined strands. The section figured is more nearly tangential than radial, and consequently these strands (*s.t.*), which sometimes anastomose, appear to extend further out from the wood than is really the case. Presumably they represent the sieve-tubes, some of which are of greater diameter than those figured. The zone in which these strands occur clearly constitutes the true phloem, while the more external part of the thin-walled tissue may be regarded as pericycle. There is no defined limit between the two.

It has already been mentioned that secondary phloem was formed from the cambium (Pl. 8. fig. 10). This is shown in longitudinal section in Pl. 10. fig. 21, from one of Prof. Oliver's slides. The plane of section is radial, and the elongated elements of the phloem are well seen, crossed by medullary rays, which are continuous with the parenchyma of the primary wood. Some of the long elements appear to have transverse walls and may represent phloem-parenchyma, while those with tapering ends are probably the sieve-tubes. No satisfactory examples of sieve-plates have been found, and perhaps the preservation is scarcely good enough to warrant our expecting them. An element (*tr.*) at the edge of the wood, with very delicate areolæ on its wall, may be a developing tracheide, such as was found in *Heterangium tiliæoides* *.

3. *Structure of the Leaf-trace Bundles.*—So far we have described the wood and phloem as occurring in the stele and meristeles, between which there is no anatomical difference. The leaf-trace strands require a separate description. Two types may be distinguished—the radially symmetrical, which is generally characteristic of the larger, more internal, strands, and the unilateral, which is typical of the smaller strands, and especially of those which have passed out towards the periphery of the leaf-base and petiole. The distinction applies chiefly to the xylem; in all cases the phloem forms a complete ring, though there may be slight differences in its distribution. An example of the radially symmetrical type of bundle is shown in Pl. 9. fig. 14, and of the unilateral type in fig. 15. The former resembles the meristeles in the fact that there are several protoxylem-groups distributed around the outside of the wood, while in the unilateral form of bundle the protoxylem is limited to one side of the wood, where it may constitute one or two groups. Transitional forms, however, may be met with. In the peripheral rank of bundles the protoxylem is regularly directed outwards, while in those of the next inner series the orientation is often reversed (fig. 16).

An important characteristic of all the bundles, to whatever type they may belong, is the presence of xylem-parenchyma among the tracheides (figs. 14 & 15), a point of distinction from the corresponding strands in the genus *Medullosa*. In this respect, as well as in their concentric structure, the bundles of *Sutcliffia* have more in common with the stele than is the case in the allied genus.

* Williamson and Scott, 1895, p. 761, pl. 29. fig. 37.

The elements of the bundle as they appear in longitudinal section are shown in Pl. 10. fig. 18, taken from one of the larger strands, a near neighbour of that shown in fig. 14, and of similar structure. The various forms of tracheide, from the large pitted elements to the spiral protoxylem, are well shown, as well as the parenchyma lying between them.

As regards the phloem there is a rather striking difference between the stele and meristeles on the one hand and the leaf-trace bundles on the other. In the former, as we have seen, the phloem-elements are generally narrow, and the sieve-tubes are by no means conspicuous in transverse section. The leaf-trace bundles, however (and the same applies to those in the petioles), show a ring of large elements in the phloem (figs. 14 & 15, *s.t.*), which strike the eye even under a slight magnification (fig. 16). Their diameter varies in different bundles; in that shown in fig. 15 the average is about 100 μ. These elements are usually separated from one another by small cells, but sometimes two or more occur in contact. Longitudinal sections show them simply as long tubes, and I have not been able to detect any characteristic markings on their walls. In the unilateral bundles of the stem the phloem is usually preserved on one side only—that remote from the protoxylem. On the other side there is a gap (fig. 15), such as one so often finds in the familiar case of *Myeloxylon*. Some of the petiolar strands are better preserved, and we can there see that the large phloem-elements extend all round the bundle, lying a little further out opposite the protoxylem, from which they are separated by small-celled tissue (see Pl. 10. fig. 22). Towards this side the phloem-elements gradually become smaller. In another case, where two bundles were close together, the large phloem-elements appeared to extend in an interrupted row from one to the other.

The question arises whether these elements were of the nature of sieve-tubes or secretory canals. Where they are all scattered, each is surrounded by a ring of small cells, recalling the secretory canals of the pericycle and cortex. On the other hand, it is not uncommon for two to be in contact, apparently separated by a single cell-wall. Further, they are entirely destitute of the dark carbonaceous contents which are so characteristic of the canals.

Another point is the gradation in size of the phloem-elements, as one proceeds from the stele to the foliar bundles. The elongated elements (presumably sieve-tubes), such as are shown in longitudinal section in fig. 20 (Pl. 10), scarcely exceed 30 μ in diameter. This is the size characteristic of the stele and meristeles, though somewhat larger sieve-tubes may occur. In some of the radially symmetrical leaf-trace strands there is little noticeable advance. In others (*e. g.* Pl. 9. fig. 14) the large elements make their appearance, but are only about 50 μ in diameter. In the unilateral strands of the leaf-bases (*e. g.* fig. 15) the diameter averages about 100 μ, while in the bundles of the petiole 130 μ is reached (Pl. 10. fig. 22). This gradation certainly suggests that the elements in question are of the same nature throughout.

Further, I am not aware of any case of a vascular strand where secretory canals form so predominant a constituent of the phloem.

For these reasons I am inclined to regard the large elements of the phloem as sieve-

tubes; we may hope that more perfect longitudinal sections may ultimately furnish decisive evidence. The position of the supposed sieve-tubes in the outer part of the phloem may seem to cast some doubt on their nature, as in most cases we are accustomed to find the small-celled protophloem towards the periphery. We have, however, an analogy in the Marattiaceæ, where, as Miss Shove and the late Mr. Brebner have shown, the protophloem is internal, and the large sieve-tubes occupy a peripheral position *.

With reference to the large size of the supposed sieve-tubes in the leaf-traces and petiolar bundles, compared with those of the stele, I have observed a similar difference in the case of *Lygodium pinnatifidum* in preparations shown me by Mr. Boodle. In other species of *Lygodium* the sieve-tubes of the leaf-traces, and of that part of the stele which is in direct communication with them, are of larger size than those in other parts of the stele.

The cortical tissue, which is identical with that of the leaf-bases, requires no detailed description. The short-celled ground-parenchyma contains numerous sacs with carbonaceous contents, and is traversed by secretory canals and strands of sclerenchyma; the latter, as already mentioned, are for the most part grouped around the vascular bundles. The hypoderma is essentially of the *Myeloxylon Landriotii* type, as in *Medullosa anglica* and other species (Pl. 9. fig. 16).

The Petioles.

A peculiar patchy form of preservation is characteristic of the vegetable remains found in roof-nodules. This is seen to some extent in the specimen of the stem of *Sutcliffia* (Pl. 7. fig. 5), though fortunately the greater part of the structure is intact in this case. The specimens of the petioles are much less favourable, for here a large part of the area of the sections is occupied by merely mineral substance, and the organic structure is limited to a peripheral band and to scattered patches of the internal tissue, though the preservation at these favoured spots is often excellent, as fig. 22 (Pl. 10) shows.

Attention has already been called to the great size of some of these petioles, which reach 12 cm. or more in diameter. Some of the sections appear to have been cut through the place where a petiole forked. The general structure is similar to that of the leaf-bases attached to the stem. The bundles, however, are more numerous, and often of large size, attaining a diameter of 3 mm. Here, as in the leaf-bases, the lateral fusion of bundles is a common phenomenon. The larger and more central bundles are of the type described above as radially symmetrical. The example figured (fig. 22) is a unilateral strand from near the periphery. There is nothing to add to the description of the bundles already given, for their structure in the leaf-base and petiole is identical. There is, however, a slight difference in the distribution of the sclerenchymatous strands around the bundles. In the leaf-base each bundle has a ring of these strands surrounding it, while in the petiole they often form a horseshoe

* Shove, 1900, p. 513, pl. 29. figs. 23, 25, & 28; Brebner, 1902, p. 542, pl. 23. figs. 20-22.

only, limited to one side of the bundle, namely, in the case of the unilateral type, the side remote from the protoxylem (fig. 22). In the leaf-bases the vascular bundles are more scattered, and so a larger proportion of sclerenchyma per bundle may be necessary for mechanical efficiency. The distinction, however, is by no means an absolute one. In some cases the sclerenchyma is merely more strongly developed on the one side, where it may form a more or less continuous arc.

One of the petioles, where the external tissues are unusually perfect, shows a distinct periderm, reaching 4 cells in thickness, and lying immediately below the small-celled epidermis, which, however, is only preserved here and there. The radial seriation is quite clear, and as the layer can be traced for a long distance, it was probably a normal formation rather than the result of a traumatic reaction. At some places the periderm-cells converge towards a slight depression of the surface, suggesting the presence of a lenticel. Lenticels are known to be formed on the petioles of Marattiaceæ *. The tissue below the periderm is ill-preserved, and no doubt consisted of thin-walled cells, which may probably have had an assimilatory function.

The sclerotic zone of the hypoderma often has the same "*Myeloxylon Landriotii*" structure as in the leaf-bases; in some places, however, this zone increases in thickness, and the radial bands of sclerenchyma are elongated, approaching the type of *M. radiatum* †.

Early in the present year I received from Mr. Peter Whalley, of Colne, Lancashire, several sections of petioles, which have proved to possess practically the same structure as the petioles of *Sutcliffia insignis* from Shore. Mr. Whalley describes the specimens as coming "from the Soapstone band, from four to seven feet above the Mountain four-feet coal-seam (Lower Coal-Measures)."

The sections are evidently from much smaller petioles than the Shore specimens, the diameter in one direction being as little as 8 mm., though, no doubt, somewhat reduced by compression. The specimens probably belong to the upper part of a petiole or to a branch of the rachis. They are well preserved, better than the Shore petioles, and all the features in the structure, as already described, are well shown. The hypoderma has radially elongated sclerotic bands, as is sometimes the case in the Shore petioles. The outer portion of one of Mr. Whalley's specimens, including the hypoderma and three of the peripheral bundles, is shown in transverse section in Pl. 9. fig. 17. The agreement with the Shore specimens will be evident on comparison with fig. 16. I see no reason to doubt that the plants from these two sources are specifically identical. It is much to be hoped that Mr. Whalley may succeed in discovering a specimen of the stem also, from the Colne locality.

An interesting question is that of the relation of *Sutcliffia insignis* to the petioles described by Mr. Seward under the name *Rachiopteris Williamsoni* (Seward, 1894). The resemblance between the Shore petioles and Mr. Seward's fossil strongly impressed me from the first, and was at once recognized by Mr. Seward himself when I showed him the sections.

* Potonié, 1881. † Renault, 1883, pl. 28.

Rachiopteris Williamsoni, which, until Mr. Seward distinguished it, had been included under *Myeloxylon*, agrees with the *Sutcliffia* petioles in the general organization, in the concentric structure of the bundles, in the position of the protoxylem, and in the presence of xylem-parenchyma; further, in the fact that the ground-tissue is traversed by sclerotic strands and secretory canals. The xylem-elements are the same in both, for tracheides with multiseriate pits are present in *R. Williamsoni*, though not specially mentioned by Mr. Seward. Even the state of preservation is similar, for in *R. Williamsoni* there is often a gap in the phloem next the protoxylem, just as is so often the case in the unilateral bundles of *Sutcliffia*. Lastly, Mr. Seward's fossil, like ours, is evidently derived from a roof-nodule, as shown by the presence of Goniatite shells. There was thus some temptation to identify the two plants, and so to confirm the opinion expressed in 1899 that "*Rachiopteris Williamsoni* was the petiole of some unknown Medullosean stem" (Scott, 1899, p. 117). Though the discovery of *Sutcliffia insignis* leaves little room for doubt that this view is correct, I do not think that the two fossils can be specifically identified. The sclerotic strands, grouped definitely round each vascular bundle, are a characteristic feature in *Sutcliffia*, whereas in *Rachiopteris Williamsoni* they are much less developed, and sometimes, in the case of the more internal bundles, wholly absent. The petiolar bundles of *Sutcliffia* are commonly more or less circular in transverse section; in the neighbourhood of a fusion they may be elongated tangentially, *i. e.* in a plane at right angles to the axis of development of the xylem. In *R. Williamsoni* the more central bundles are often markedly elliptical, the long axis passing through the protoxylem. The difference is, of course, far from being an absolute one, but it is sufficient to give a somewhat different habit to the transverse sections.

Lastly, the large elements regarded as sieve-tubes, which form a conspicuous feature in the bundles of *Sutcliffia*, are by no means so well marked in *R. Williamsoni*, as an inspection of Mr. Seward's figs. 7 & 8 will show. Similar elements no doubt occur, but they are smaller and much more scattered. The differences just pointed out are not, perhaps, very important, but they appear to be sufficient for specific distinction.

Mr. Seward lays great stress on the presence of "bundle-canals" in *R. Williamsoni*, belonging to the peripheral part of the phloem, rather than to the fundamental tissue (Seward, 1899, p. 212). In many cases the "canal" appears in transverse section as a small group of cells, gradually separating from a central point, or in other cases showing distinct indications of disorganization (*l. c.* p. 213, figs. 11–13). Mr. Seward regards the different conditions observed as stages of a schizolysigenous process, leading to the formation of a secretory canal. I have occasionally detected similar structures in the phloem of the bundles in *Sutcliffia*, and have also examined the conditions in *Rachiopteris Williamsoni*. I have some doubt as to the interpretation of these structures as developing canals. It is not easy to see why such early stages of development (even if likely to be preserved) should be met with in a mature organ, where there is no question of secondary growth. I should rather incline to the view that these little nests of cells may represent strands of small sieve-tubes, more or less imperfectly preserved.

In spite of the differences to which attention has been called, there is no doubt of the close affinity of *Rachiopteris Williamsoni* with *Sutcliffia insignis*, and I have little hesitation in placing the former in the genus *Sutcliffia*, under the name *Sutcliffia Williamsoni*.

Summary.

Sutcliffia insignis was a large stem, probably of considerable height, the surface clothed by spirally arranged leaf-bases of great size relative to the stem.

The vascular system of the stem consisted of a single main stele with solid wood (protostele), from which meristeles or subsidiary steles were given off.

The meristeles divided up, the branches of adjacent meristeles sometimes fusing with one another, and gave rise to the numerous leaf-trace bundles.

The xylem in all parts of the vascular system was exarch, and consisted of tracheides interspersed with xylem-parenchyma. The walls of the larger tracheides bore multiseriate bordered pits. The formation of secondary wood and bast had begun to a small extent around the stele and some of the meristeles. The phloem of the stele and meristeles consisted of strands of narrow elements (sieve-tubes) embedded in parenchyma. In the bundles of the leaf-bases and petioles numerous large phloem-elements, probably of the nature of sieve-tubes, were present. The pericycle and cortex were traversed by secretory canals. The leaf-bases and detached petioles were of similar structure, the hypoderma having radially arranged sclerotic bands as in *Myeloxylon*; other sclerotic strands traversed the ground-tissue. The foliar bundles, which were present in great numbers in the petiole, were in all cases of concentric structure.

Diagnosis.

SUTCLIFFIA, gen. nov.

Surface of the stem clothed by the large, spirally-arranged leaf-bases; vascular system of stem consisting of a single protostele, giving off meristeles, which branch and undergo fusion, ultimately giving rise to the leaf-traces.

Xylem exarch. Tracheides mostly with multiseriate bordered pits. Leaf-bases and petioles with the general organization of *Myeloxylon*, but all vascular bundles concentric.

SUTCLIFFIA INSIGNIS, sp. nov.

Petiolar bundles approximately circular in transverse section, each of them invested by a ring or horseshoe of sclerenchymatous strands; phloem containing numerous large elements, forming a conspicuous circle round the bundle, and probably representing the sieve-tubes.

Stem, in the one specimen known, $12 \times 6{\cdot}5$ cm. in diameter. Detached petioles sometimes exceeding 12 cm. in diameter.

Localities. Shore-Littleborough and Colne, Lancashire.

Horizon. Lower Coal-Measures.

I have given above the specific characters which may serve to distinguish *Sutcliffia insignis* from *S. Williamsoni* (Seward).

Affinities.

Sutcliffia is referred to the family Medulloseæ on account of the general organization of the leaf-bases and petioles, the course of the leaf-trace bundles, the tendency to dialystely shown by the formation of the subsidiary steles or meristeles, and the histology both of the vascular and cortical tissues *. The genus differs from the other members of the family in the stem having a single main stele in a central position and in the concentric structure of the foliar bundles. The former character is unique in the family, for although *Colpoxylon* has a single stele in part of the stem, its irregular outline suggests a local fusion of the two or more steles that occur in other parts of the specimen †. Concentric petiolar bundles have not been described in any other member of the family (apart from *Sutcliffia Williamsoni*). In *Steloxylon Ludwigii*, however, according to Count Solms-Laubach's interpretation of its structure, branches of the steles, instead of single bundles, enter the petioles from the stem ‡, so there would appear to be a possible analogy in this respect with *Sutcliffia*, though the complexity of the stem-structure in *Steloxylon* forbids any further comparison.

The question of the homologies of the parts of the vascular system in *Sutcliffia* has been discussed above (p. 53). As there are no features pointing to reduction from a more complex structure, the view is taken that the main stele represents the original protostele, such as we find in *Heterangium*, while the meristeles constitute a subsidiary peripheral system, differentiated to meet the demands of the megaphyllous foliage for an elaborate vascular supply. Thus we may, if we will, interpret the structure of *Sutcliffia* as dialystelic, but it is peculiar in the fact that the original central stele still remains dominant. I am not aware of any analogous case, either fossil or recent, among Cycadofilices or Ferns. Where we find concentric cylinders, or zones in the stems of Ferns, the central strand is found to be subsidiary, arising from a more peripheral vascular zone §. This depends on the fact that throughout the Fern-series dialystely is attained by the expansion of the original stele into a tube (siphonostele of Jeffrey), which becomes broken up by the leaf-gaps. *Sutcliffia* appears to represent the unique case of dialystely without siphonostely. Analogies may no doubt be found in species of *Selaginella* ‖, but in these microphyllous forms the conditions are so widely different that the comparison cannot be profitably pursued. I do not desire, however, to press the dialystelic interpretation of *Sutcliffia* too strongly; there are no absolute distinctions in anatomy, and the meristeles of *Sutcliffia* may be regarded as transitional between leaf-traces and "steles." In trying to determine the position of the new genus among the Medulloseæ we must take into account the characters of the petiole, as well as those of the stem. As regards the petiole, the main feature is the concentric structure of the vascular bundles; the presence of xylem-parenchyma is another point of interest, though of secondary importance. In both respects the foliar bundles retain more of a

* Scott, 1900, p. 374.

† Renault, 1896, p. 301, pl. 67.

‡ Solms-Laubach, 1897, p. 197.

§ Gwynne-Vaughan, 1903; Tansley, 1905.

‖ Harvey-Gibson, 1894.

stelar character than those of *Medullosa*. The unilateral strands, with their external protoxylem, bear a considerable resemblance to those of an ordinary *Myeloxylon*, suggesting a doubt whether their concentric structure is primitive; from their appearance they might conceivably have been derived from bundles that were once collateral. This, however, is a very unlikely hypothesis, considering the gradation that exists from the stele to the unilateral bundles. It is much more probable, as all analogy indicates, that the foliar bundles of *Sutcliffia* were on the up-grade of development, and that the unilateral structure of the wood may have preceded collaterality of the bundle as a whole.

Taking all the characters into consideration, I should be inclined to regard *Sutcliffia* as the most primitive member of the Medulloseæ yet discovered; it is doubtful, however, whether it lay on the direct line of descent of any of the more complex types with which we are acquainted. It may be well to repeat here the warning already given (p. 54), that the adult structure of *Sutcliffia* itself may have been more complex than that shown in our solitary specimen.

The exarch structure of the stele appears to have been common to some other Medulloseæ, e. g., *M. Leuckarti* *, while *M. anglica* was somewhat mesarch in the stele, though exarch as regards the leaf-trace bundles †. The distinction is not, in any case, a very marked one in this group.

Sutcliffia, if we interpret its structure rightly, had not advanced very far beyond the simple protostelic condition which we find represented in *Heterangium* among the Lyginodendreæ, or, in a more specialized form, in Seward's *Megaloxylon*. This is a point of some importance, as indicating that the whole course of evolution from the protostele to the most élaborate dialystelic type may have been gone through within the family Medulloseæ. In order to explain the origin of the peculiar Medullosean anatomy it is no longer necessary to go so far afield as the Botryopterideæ, for example. The Medulloseæ are their own interpreters.

The discovery of *Sutcliffia* appears to add probability to the suggestion that the Medulloseæ, as well as the Lyginodendreæ, may have sprung from a type anatomically similar, apart from details, to *Heterangium* ‡. But this must only be taken in the most general sense. *Heterangium*, with the xylem-strands of its leaf-traces already marked out in the stele itself, had probably advanced some little way in the direction of *Lyginodendron*, and no longer represents the common type with any exactness. So far, however, as the anatomical evidence indicates, the probability is that Lyginodendreæ and Medulloseæ may have had a common origin from a point not very far below the level of stems such as those of *Sutcliffia* and *Heterangium*. On the other hand, the evidence for the direct derivation of the Medulloseæ from a simple monostelic type tends to remove them further from the Cladoxyleæ, ancient and markedly dialystelic forms §, which may well, as has recently been suggested, find their nearest allies among some of the Botryopterideæ.

* Solms-Laubach, 1897, p. 180, pl. 6. fig. 2.

† Scott, 1899, p. 89, pl. 10. fig. 5.

‡ Scott, 1899, p. 118.

§ Solms-Laubach, 1896.

The photographic illustrations to this paper are by my colleague, Mr. L. A. Boodle, F.L.S., to whom I am much indebted for the trouble he has taken to obtain the best possible results. The drawings for the figures in Plate 10 are from the skilful hand of Mr. John Allen, of Kew.

Addendum.

Since the paper was sent in to the Society I have seen a number of additional sections, cut by Mr. Lomax, from the two ends of the original specimen, and therefore beyond the limits of the series on which my observations have been based. From the upper end, above transverse Section XVII., no less than eleven additional sections * have been cut, forming an important extension of the transverse series. Unfortunately I have still been unable to find any decisive evidence of the giving off of a petiole from the stem. The large leaf-base, lying between *d.r.* and *d.r.'* (Pl. 8. fig. 6) disappears, it is true, but its disappearance is due to decay. It is therefore impossible to tell whether a real separation took place within this region. No other leaf-base becomes free.

As regards the course of the meristeles, the division of the meristele α, indicated in Section XVII. (fig. 6), is completed, and the outer portion at once divides into two. No further change could be detected. The meristele B gives off yet another bundle from the right-hand end (fig. 6). The new sections confirm the opinion expressed on p. 52, that the small meristele β' does not really undergo fusion with the stele, but has merely been mechanically forced into its tissue. The same thing has happened to a small Goniatite shell close by.

From the lower end of the specimen, below Section I. of our series, two further transverse sections (W I. and W II.) have been cut. They agree with Mr. Watson's section (No. I.) except in one point, which, however, is important. The meristele on the right, lying next above γ (see fig. 1), is undivided in Section I.; in the first of the new sections, W I., it shows signs of splitting into two; and in the lowest section, W II., it has divided into two nearly equal parts. As the division is found on tracing the meristele *downwards*, the case is evidently really one of *fusion* in the upward direction, and thus affords an interesting parallel to the fusion of the meristeles β and γ described in the text. The occurrence of these fusions is evidently characteristic of the meristeles in *Sutcliffia*. Eight additional longitudinal sections have been cut from the lower extremity of the specimen. The various tissues are well shown, but there are no new features to be recorded.

It will thus be seen that the new sections confirm, but in no way modify, the conclusions arrived at from the examination of the original series.

D. H. Scott.

May 7, 1906.

* These sections are lettered in order, from below upwards, from A 1 to J.

References.

Boodle, 1901. L. A. Boodle, "Comparative Anatomy of the Hymenophyllaceæ, Schizæaceæ, and Gleicheniaceæ.—II. On the Anatomy of the Schizæaceæ." Ann. of Bot. vol. xv.

Brebner, 1902. G. Brebner, "On the Anatomy of *Danæa* and other Marattiaceæ." Ann. of Bot. vol. xvi.

Gwynne-Vaughan, 1903. D. T. Gwynne-Vaughan, "On the Anatomy of Solenostelic Ferns.—II." Ann. of Bot. vol. xvii.

Harvey-Gibson, 1894. R. J. Harvey-Gibson, "Contributions towards a Knowledge of the Anatomy of the Genus *Selaginella*.—Part I. The Stem." Ann. of Bot. vol. viii.

Jeffrey, 1902. E. C. Jeffrey, "The Structure and Development of the Stem in the Pteridophyta and Gymnosperms." Phil. Trans. Roy. Soc., Series B, vol. 195.

Potonié, 1881. H. Potonié, "Anatomie der Lenticellen der Marattiaceen." Jahrbuch d. k. Bot. Gartens, Berlin, Bd. i.

Renault, 1883. B. Renault, 'Cours de Botanique Fossile,' 3me Année : Fougères.

Renault, 1896. 'Bassin Houiller et Permien d'Autun et d'Épinac.—Flore Fossile,' 2me Partie.

Scott, 1899. D. H. Scott, "On the Structure and Affinities of Fossil Plants from the Palæozoic Rocks. —III. On *Medullosa anglica,* a new Representative of the Cycadofilices." Phil. Trans. Royal Soc., Series B, vol. 191.

Scott, 1905. Ditto.—V. "On a new Type of Sphenophyllaceous Cone (*Sphenophyllum fertile*) from the Lower Coal-Measures." Ibid. vol. 198.

Scott, 1900. Studies in Fossil Botany.

Scott, 1904. "On the Occurrence of *Sigillariopsis* in the Lower Coal-Measures of Britain." Ann. of Bot. vol. xviii.

Scott, 1905. "The Early History of Seed-bearing Plants, as recorded in the Carboniferous Flora." Wilde Lecture. Memoirs of the Manchester Lit. & Phil. Soc. vol. xlix. no. 12.

Seward, 1894. A. C. Seward, "On *Rachiopteris Williamsoni*, sp. nov., a new Fern from the Coal-Measures." Ann. of Bot. vol. viii.

Seward, 1899. "Notes on the Binney Collection of Coal-Measure Plants.—Part II. *Megaloxylon*." Proc. Cambridge Phil. Soc. vol. x.

Shove, 1900. Miss R. F. Shove, "On the Structure of the Stem of *Angiopteris evecta*." Ann. of Bot. vol. xiv.

Solereder, 1899. H. Solereder, 'Systematische Anatomie der Dicotyledonen.'

Solms-Laubach, 1896. H. Graf zu Solms-Laubach, "Pflanzenreste des Unterculm von Saalfeld in Thüringen." Abhandl. der k. Preuss. Geol. Landesanstalt, neue Folge, Heft 23.

Solms-Laubach, 1897. "Ueber *Medullosa Leuckarti*." Bot. Zeitung, Jahrgang 55, Abth. i.

Tansley, 1905. A. G. Tansley, "Anatomy of *Matonia pectinata*." Ann. of Bot. vol. xix.

Watson, 1906. D. M. S. Watson, "A 'Fern'-synangium from Shore." Journal of the Royal Microscopical Society, Feb. 1906.

Williamson and Scott, 1895. W. C. Williamson and D. H. Scott, "Further Observations on the Organization of the Fossil Plants of the Coal-Measures.—III. *Lyginodendron* and *Heterangium*." Phil. Trans. Roy. Soc., Series B, vol. 186.

EXPLANATION OF THE PLATES.

Plates 7–9, photographs by Mr. L. A. Boodle, F.L.S.

Figs. 1–5 (Pl. 7) and fig. 6 (Pl. 8) are selected from the series of transverse sections, numbered from below upwards (see table on pp. 46–47).

Plate 7.

Fig. 1. Stele and surrounding tissues from Section III. The stele is surrounded by meristeles of various dimensions. α, β, future meristeles, which at this level are still in connection with the stele; $\beta\beta$, a minor meristele, just detached from β; γ, meristele which subsequently fuses with β; δ, another meristele (see Pl. 10. fig. 19); *m*, small meristele which subsequently divides up into bundles (see Pl. 8. fig. 7). × nearly $1\frac{1}{2}$.

Fig. 2. From Section V. (Prof. Oliver's, O. 35). β', meristele detached from β, which is just becoming free; *m.b.*, three bundles derived from the meristele *m.*; other lettering as before. × nearly $1\frac{1}{2}$.

Fig. 3. From Section VIII. α shows signs of separation from the stele and division into two; β and β' quite free; γ has given off bundles above and below; *m.b.*, bundles more widely separated (see Pl. 8. fig. 8). × nearly $1\frac{1}{2}$.

Fig. 4. From Section IX. (Miss Stopes's). α is now free and α' is detached from it; β is fusing with γ. × nearly $1\frac{1}{2}$.

Fig. 5. From Section X. (Prof. Weiss's). Complete transverse section, including the cortex and leaf-bases. α' has here divided into two; B, the fused meristele composed of β and γ; B′, small meristele detached from B; *d.r.*, *d.r.′*, double rows of leaf-trace bundles, referred to in text (p. 49); *v.b.*, two foliar bundles fusing. × nearly $1\frac{1}{2}$.

Plate 8.

Fig. 6. From Section XVII. (uppermost of series). Parts of the cortex and leaf-bases are included. α is here beginning to divide into two; B is giving off another bundle on the right; *d.r.*, *d.r.′*, the double rows of bundles, which here appear to mark the limits of a leaf-base. × nearly $1\frac{1}{2}$.

Fig. 7. α-region of stele from Section III., enlarged; $\alpha\alpha$, portion of α about to become detached; *m.*, small meristele, which divides up at a higher level; *b.*, bundle probably derived from *m.* × about 4.

Fig. 8. α-region from Section VIII., enlarged. *p.x.*, protoxylem-group on inner surface of α; *m.b.*, three bundles derived from the division of the meristele; *b.*, bundle previously free. × about 4.

Fig. 9. β-region of stele from Section IX., enlarged, showing the fusion of β with γ. γ', bundle previously derived from γ; β', part of β previously detached. × about 4.

Fig. 10. Portion from outer part of stele, to show secondary growth beginning. *x*, primary wood; *px.*, protoxylem-group; x^2, secondary wood; *cb.*, cambium; $ph.^2$, secondary phloem. Section IV. × 55.

Plate 9.

Fig. 11. Portion from exterior of stele, to show protoxylem. *px.*, two protoxylem-groups. The tracheides and parenchyma of the primary wood are seen to the interior. Section I. (Mr. Watson's). × about 30.

Fig. 12. Longitudinal section from primary wood of stele, to show elongated forms of tracheides, differing from that in *Megaloxylon*. Section M. × about 4.

Fig. 13. Longitudinal section from primary wood of stele, to show the xylem-parenchyma, which contains secretory sacs. From a section of Prof. Oliver's, University College, London, O. 36 C. × about 60.

Fig. 14. Transverse section of a radially symmetrical bundle from a leaf-base. Note the parenchyma in the xylem and the large phloem-elements, *s.t.*; *f.s.*, fibrous strands. From Section XIII. × about 40.

Fig. 15. Transverse section of a unilateral bundle from a leaf-base. *px.*, protoxylem; *s.t.*, large elements of the phloem. From Section XIII. × about 50.

Fig. 16. Transverse section of part of a leaf-base. *hy.*, hypoderma; *v.b.*, vascular bundles, with sclerotic strands surrounding them. From Section X. The part figured here will be found on the lower side of fig. 5, to the left. × about 6.

Fig. 17. Transverse section of part of a petiole from Colne, showing hypoderma, vascular bundles, and sclerotic strands, to compare with fig. 16. From a section received from Mr. Peter Whalley. × about 8.

Plate 10.

Drawings by Mr. John Allen.

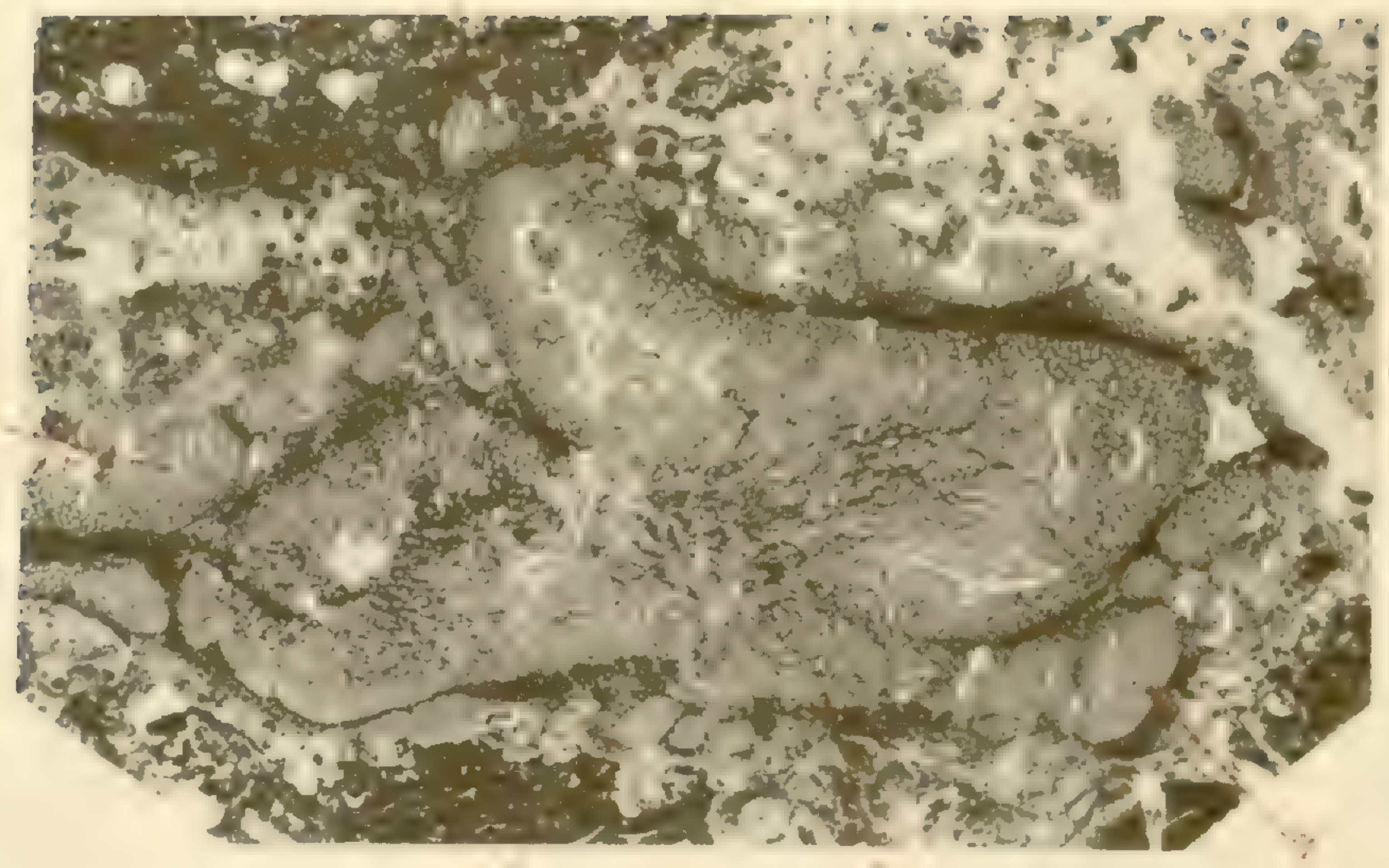
Fig. 18. Longitudinal section of a radially symmetrical bundle from a leaf-base (similar to that shown in fig. 14, in transverse section). *ph.*, phloem; *px.*, protoxylem, succeeded to the left by more densely spiral tracheides, and then by the large pitted elements and parenchyma that constitute the xylem. The bundle is not quite complete on the left. From Section C. × about 80.

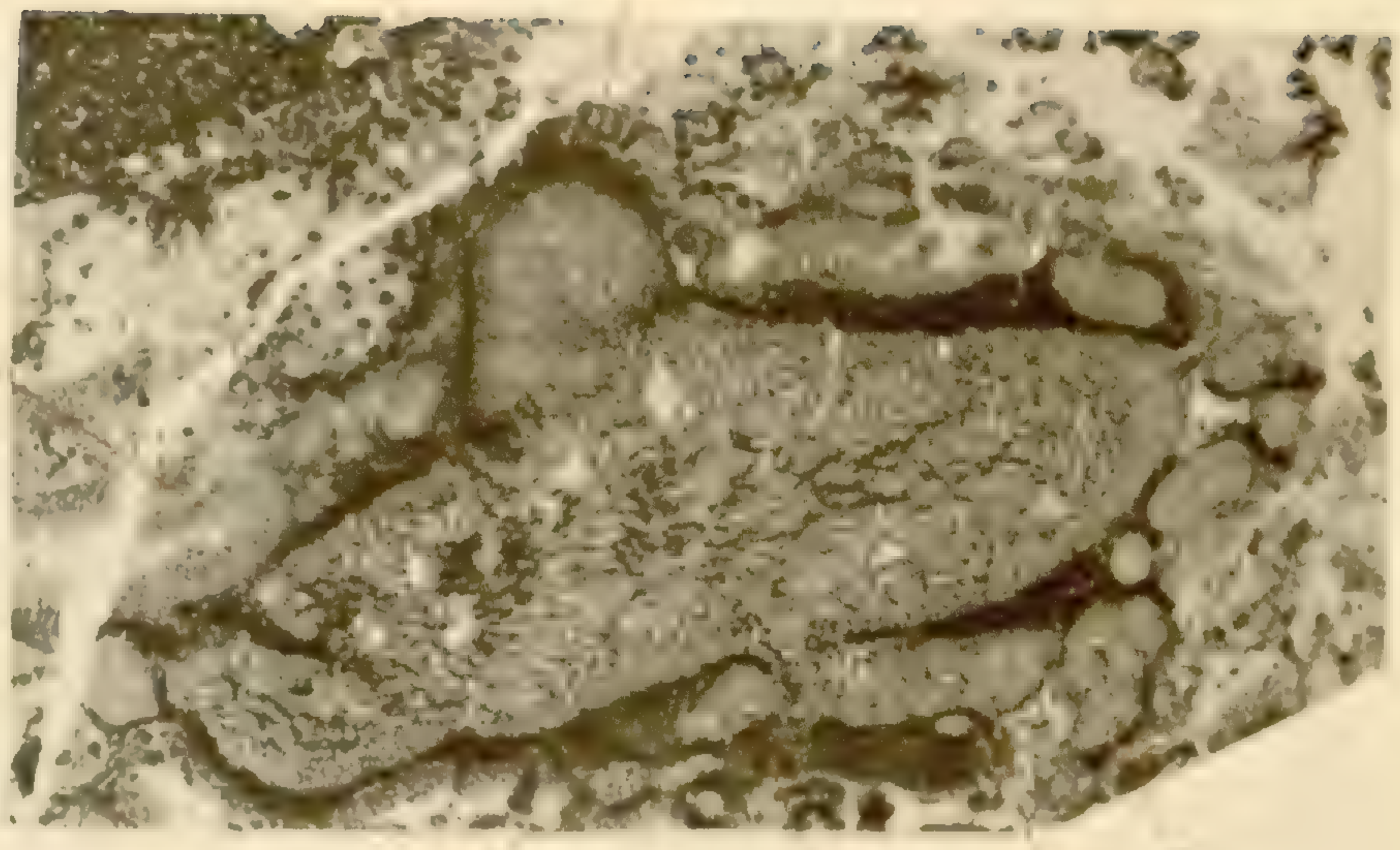
Fig. 19. Transverse section from the exterior of the large meristele, shown in fig. 1. The edge of the wood is seen above. *st.*, probable strand of sieve-tubes; *s.c.*, one of the secretory canals, of which three are seen in a row in the pericycle. The phloem passes over insensibly into the pericycle. From Section IV. × about 55.

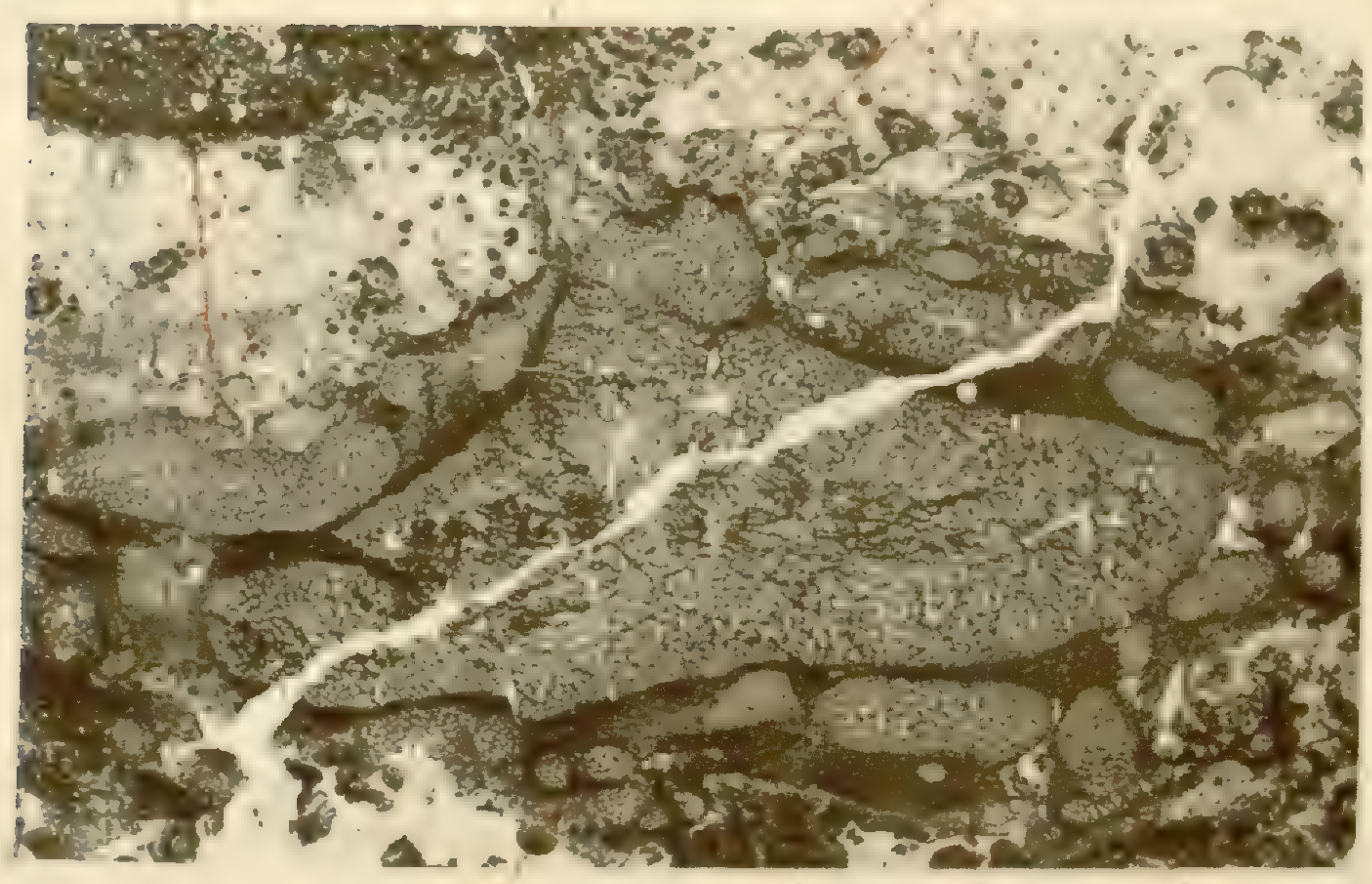
Fig. 20. Nearly tangential section through the phloem of the meristele. The wood lies immediately to the right. *s.t.*, branching strand of narrow elements, no doubt including the sieve-tubes; *s.c.*, secretory canals. From Section I. × about 60.

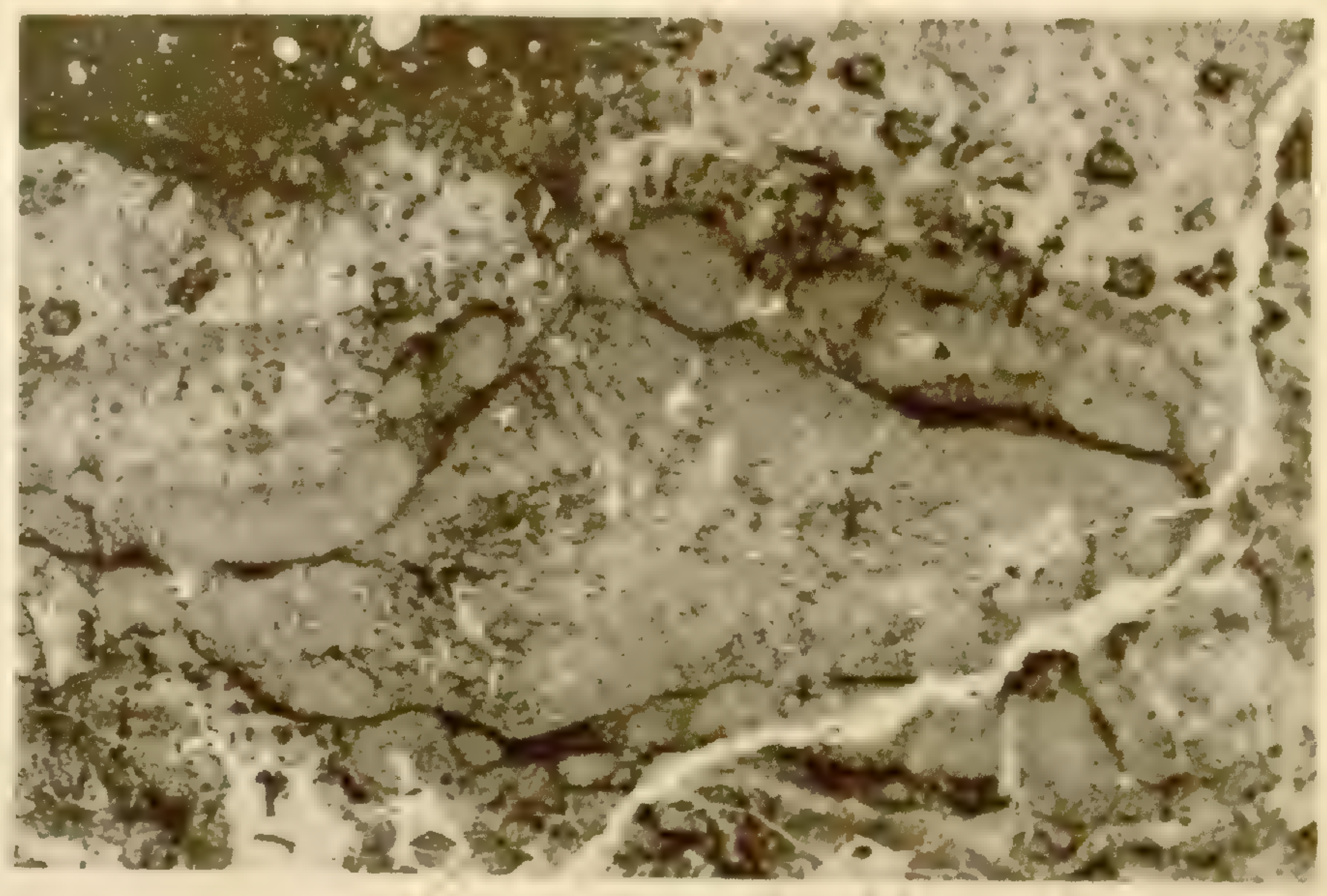
Fig. 21. Radial section through the outer part of the stele, where secondary growth is going on. *tr.*, secondary tracheide, with delicate pit-borders; *ph.*, secondary phloem; *m.r.*, two medullary rays, crossing the secondary xylem and phloem, and abutting on the parenchyma of the xylem and pericycle. From one of Prof. Oliver's sections, University College, London, O. 36 b. × about 100.

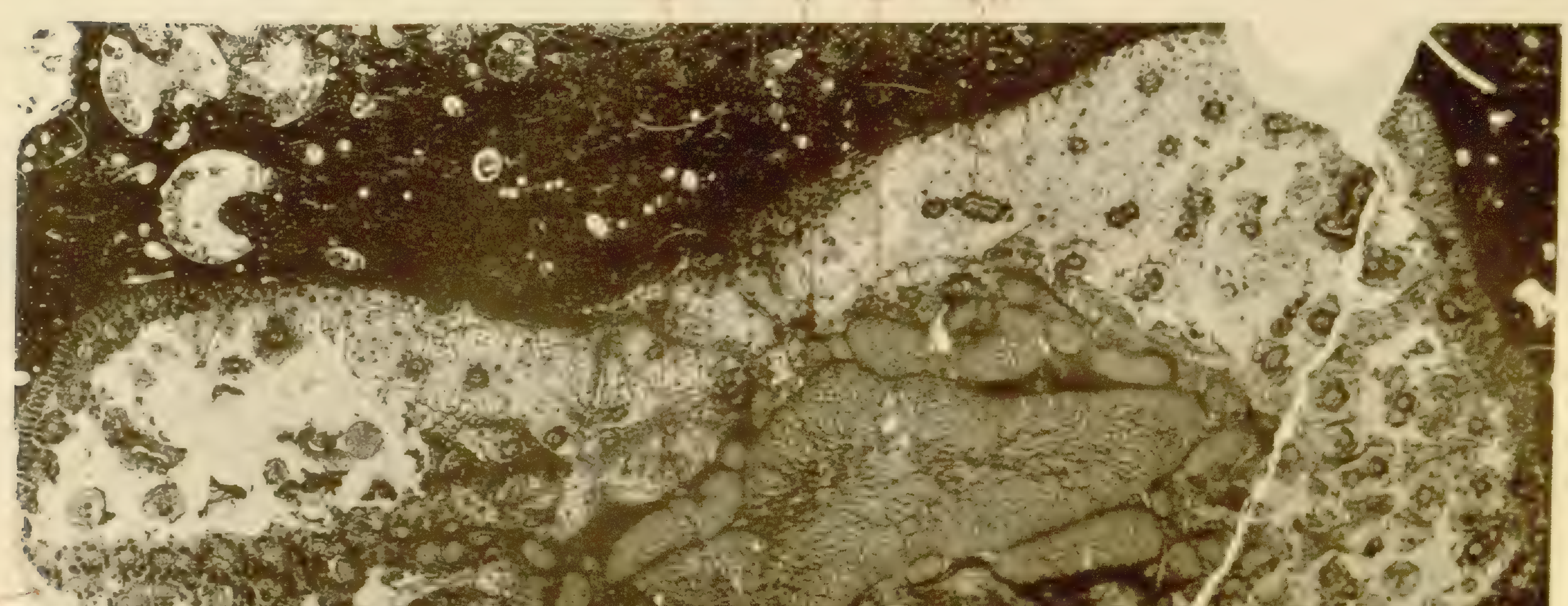
Fig. 22. Transverse section of a vascular bundle in a petiole from Shore. *px.*, protoxylem; *s.t.*, large phloem-elements, which form a ring round the xylem; *f.s.*, sclerotic strands accompanying the bundle. Section 5. × about 30.



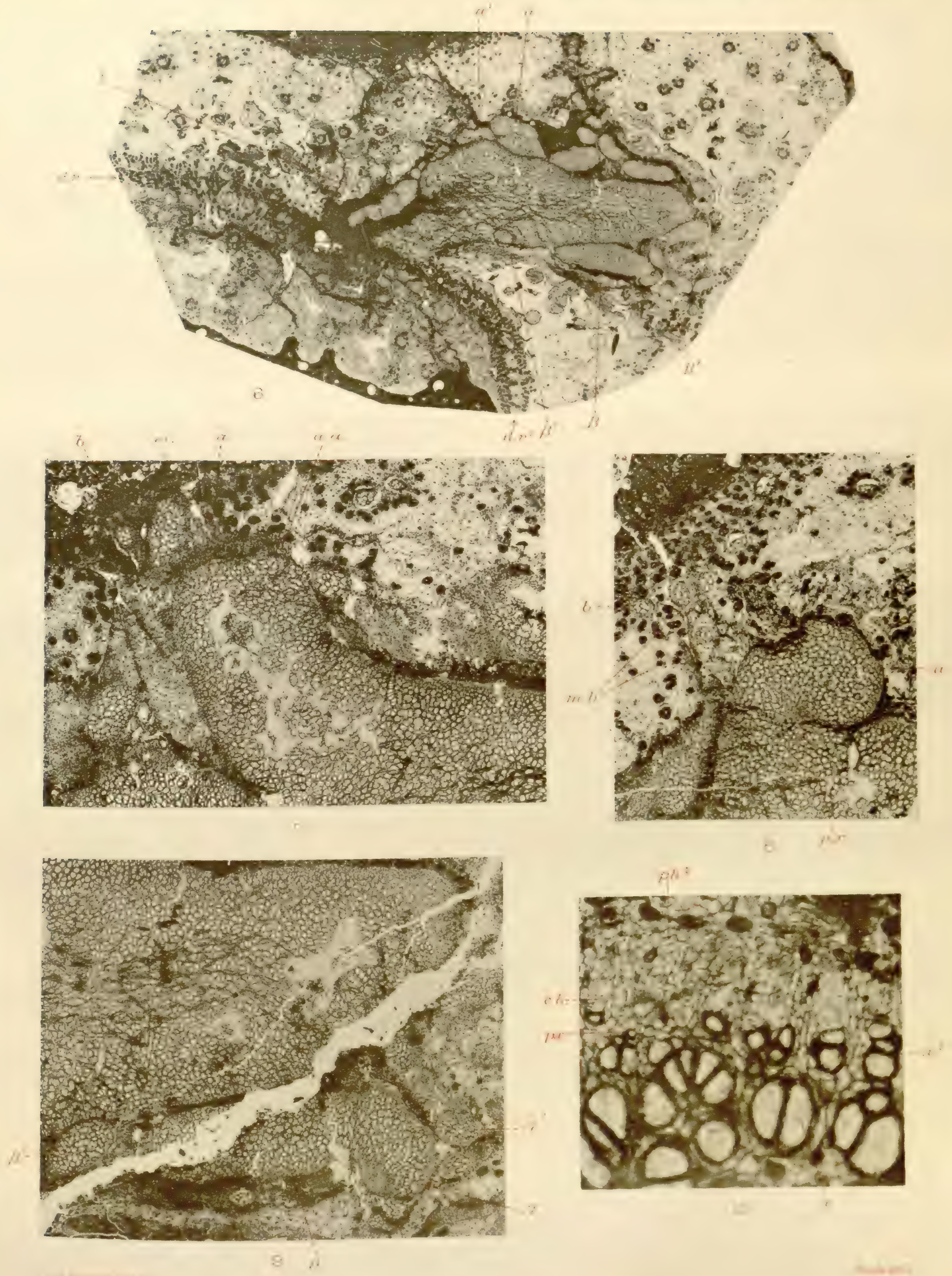






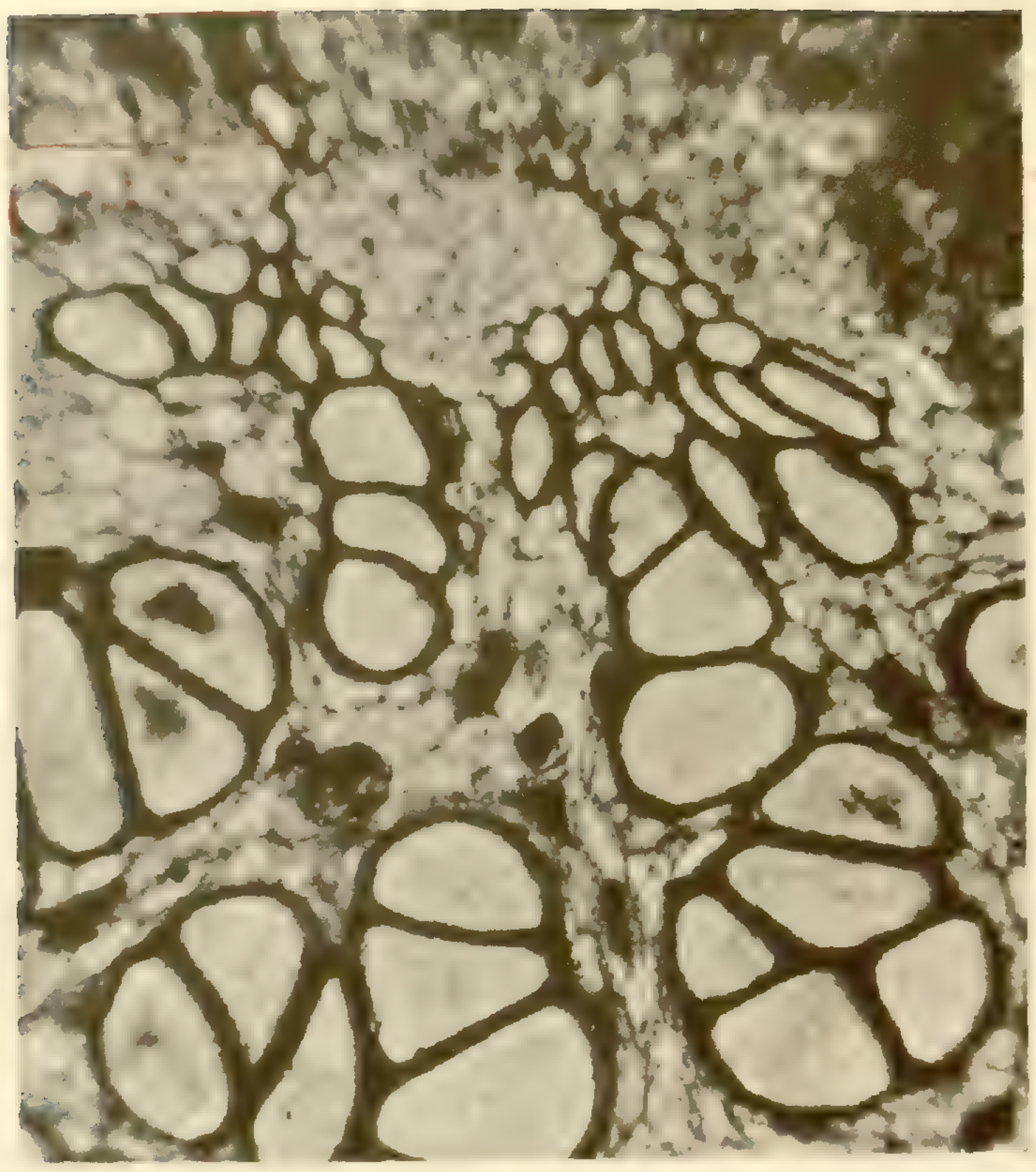


SUTCLIFFIA INSIGNIS.



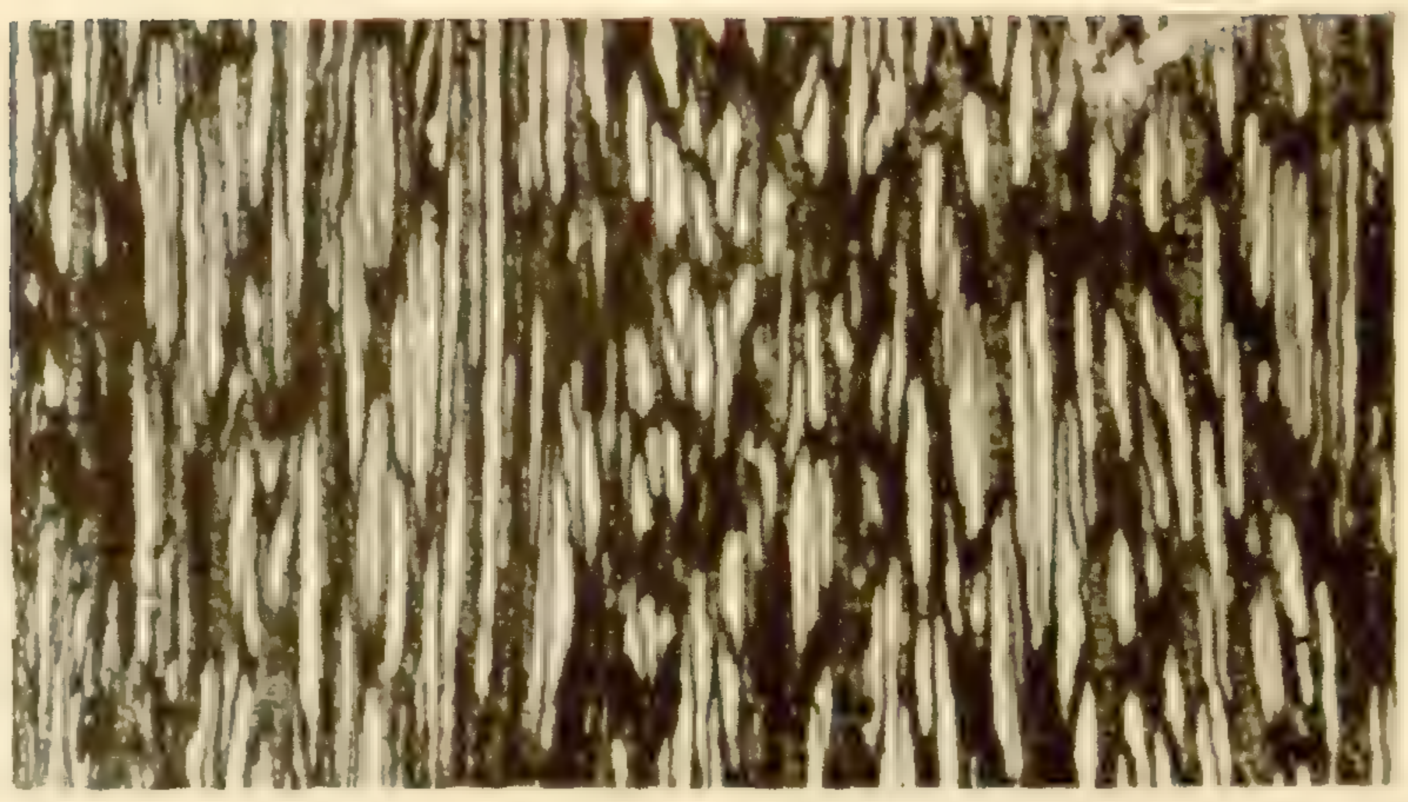
SUTCLIFFIA INSIGNIS.

px.



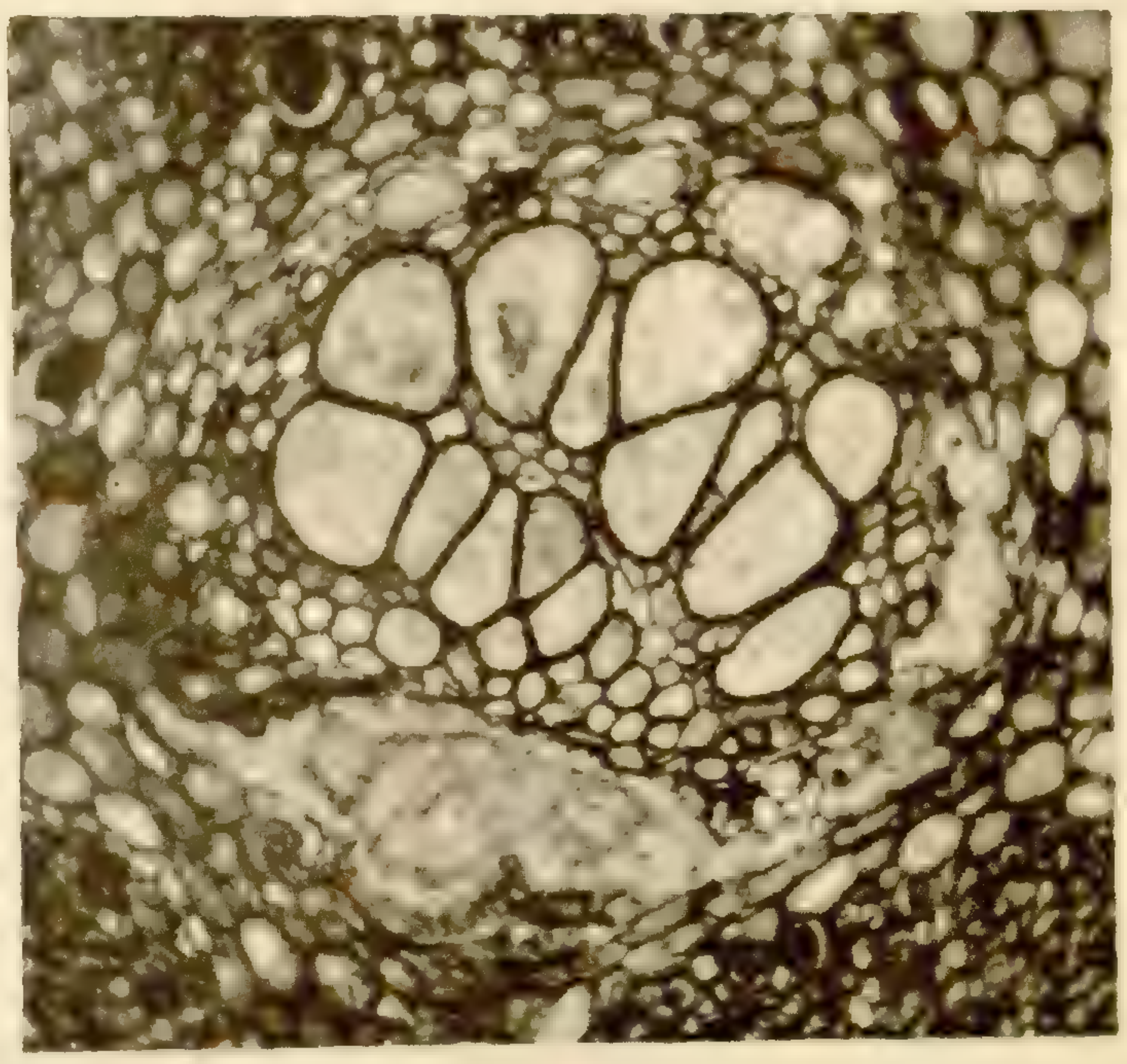
px.

11



12

s.t.



s.t.

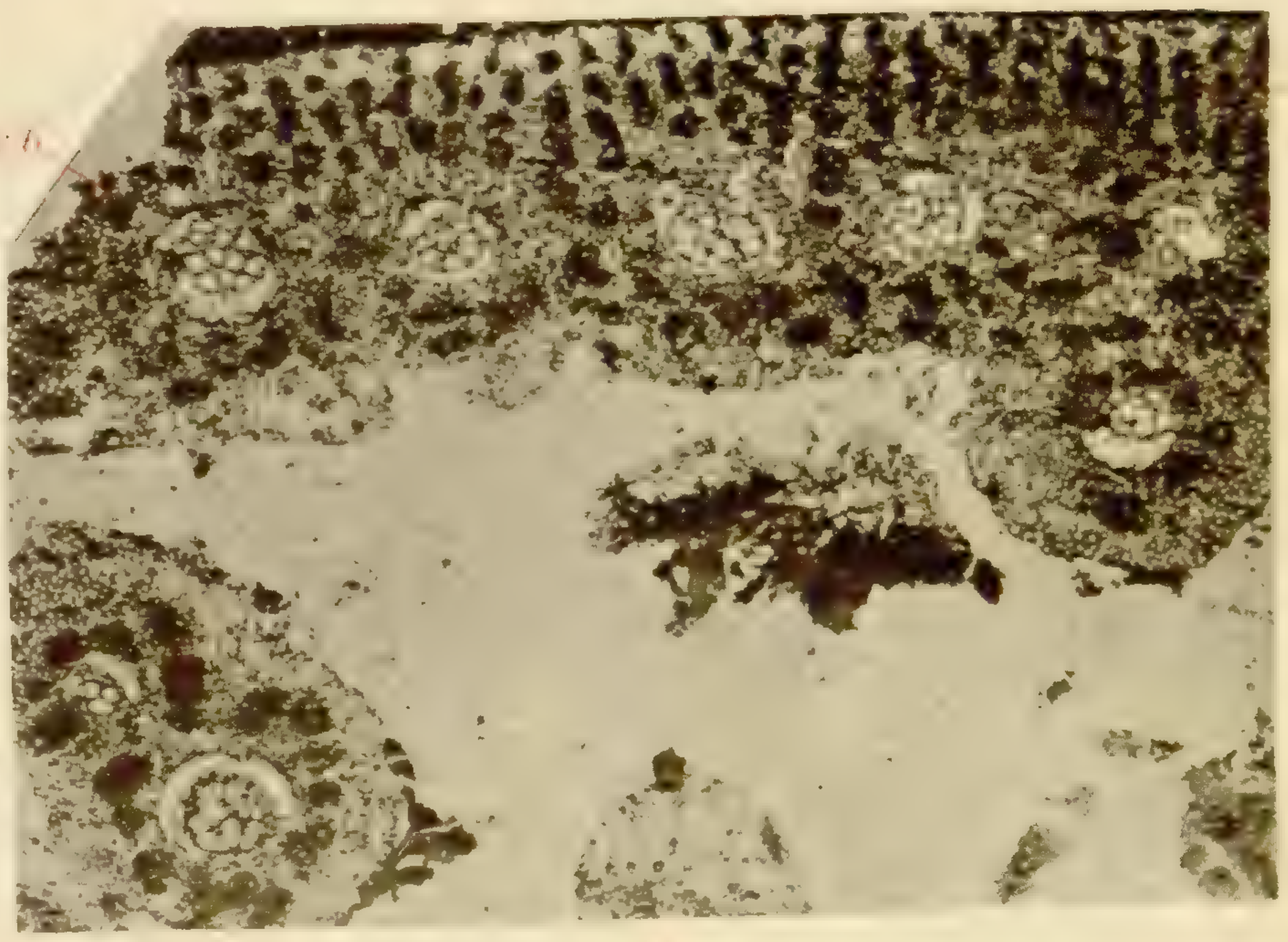
p.x.

15

13

v.b.

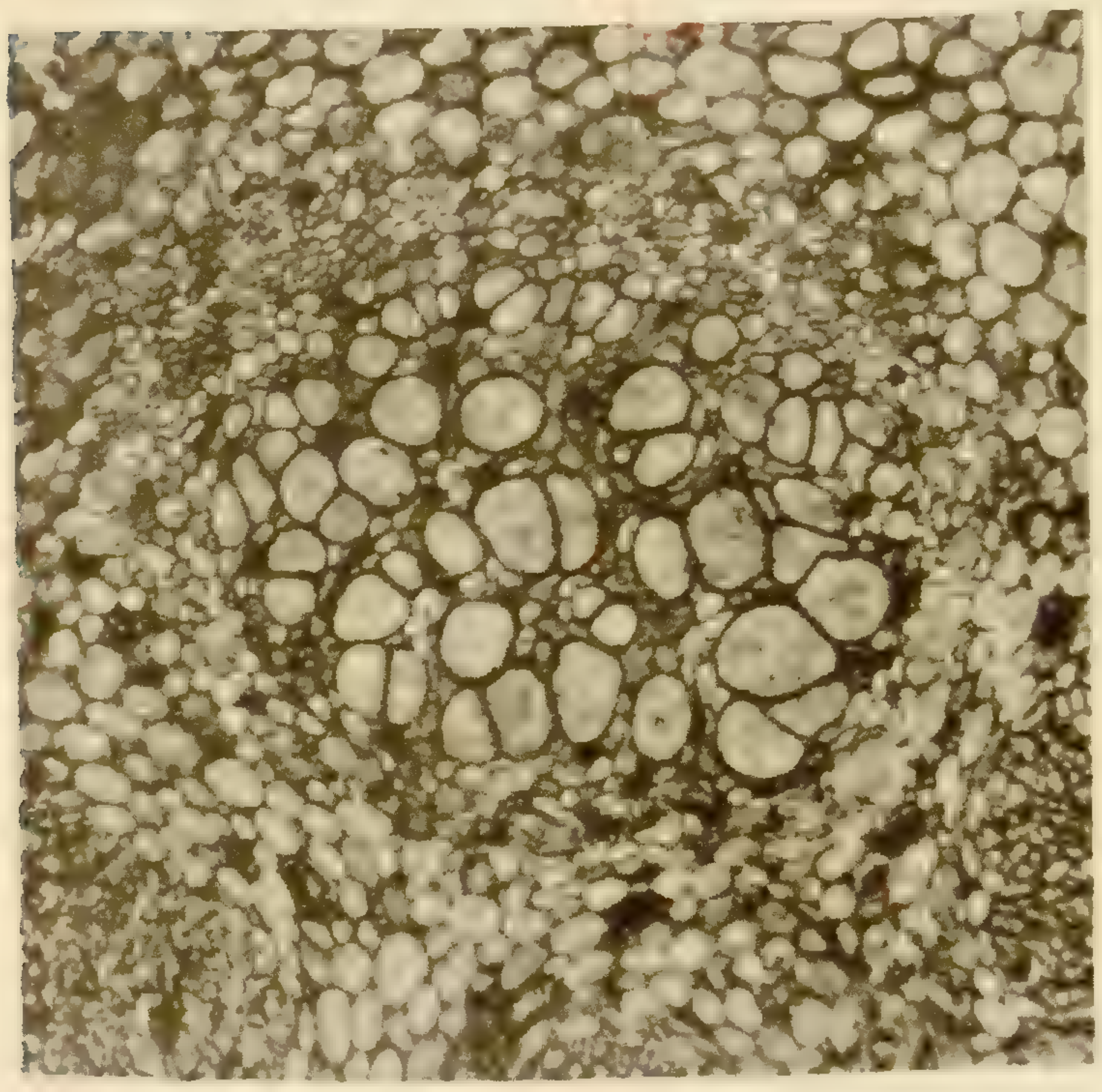
h.y.



v.b.

16

s.t.



s.t.

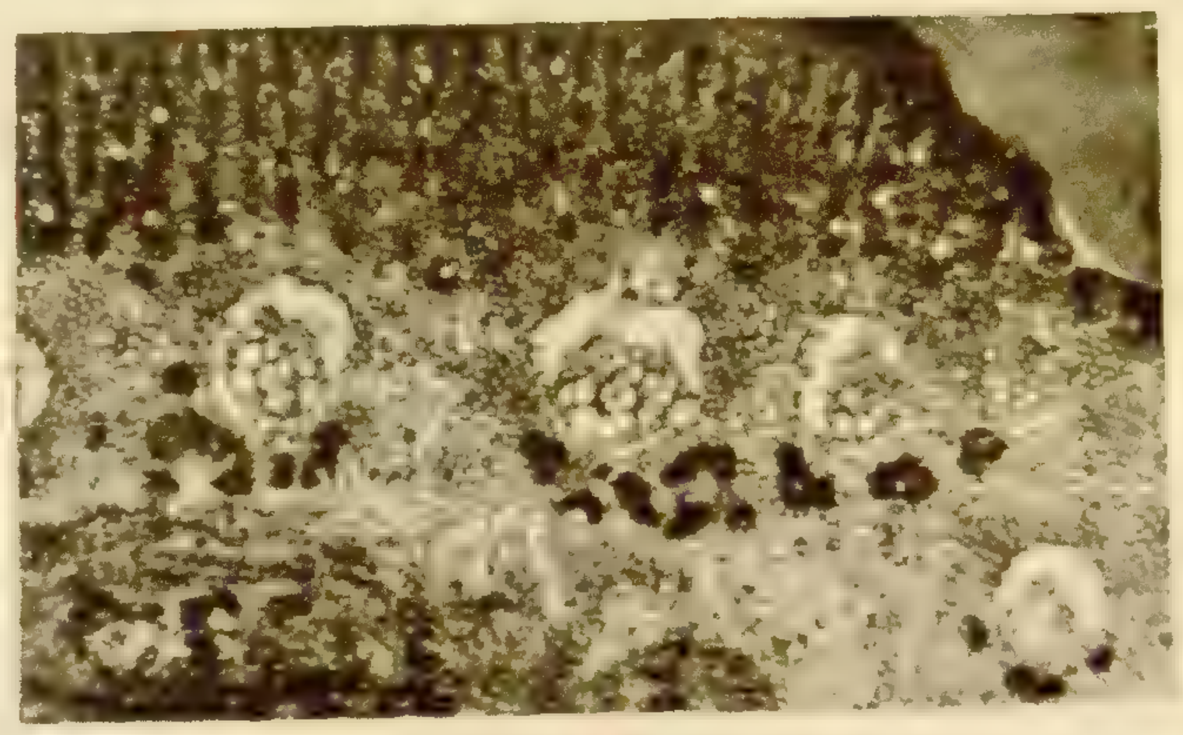
l.s.

l.s.

14

hy.

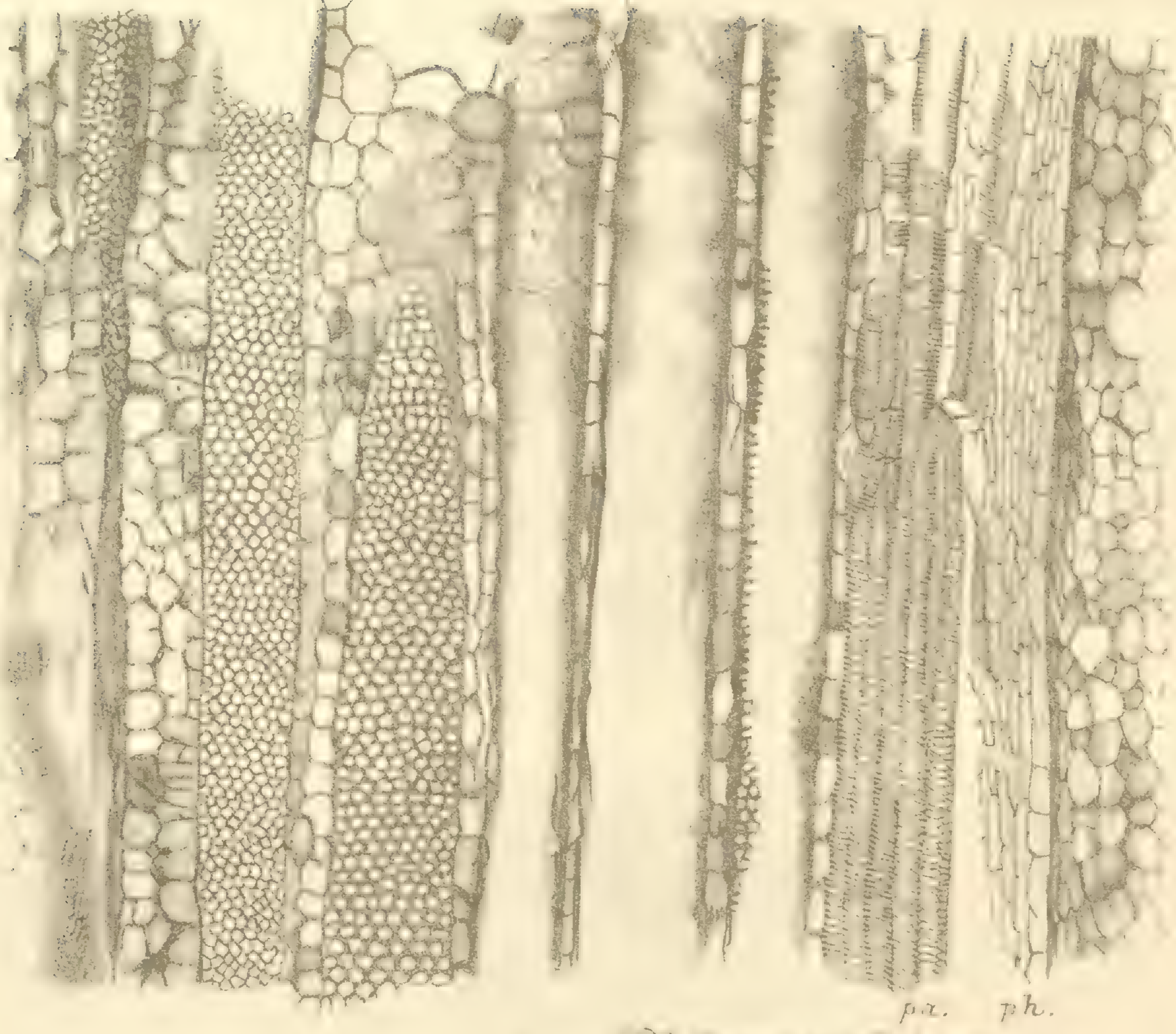
v.b.



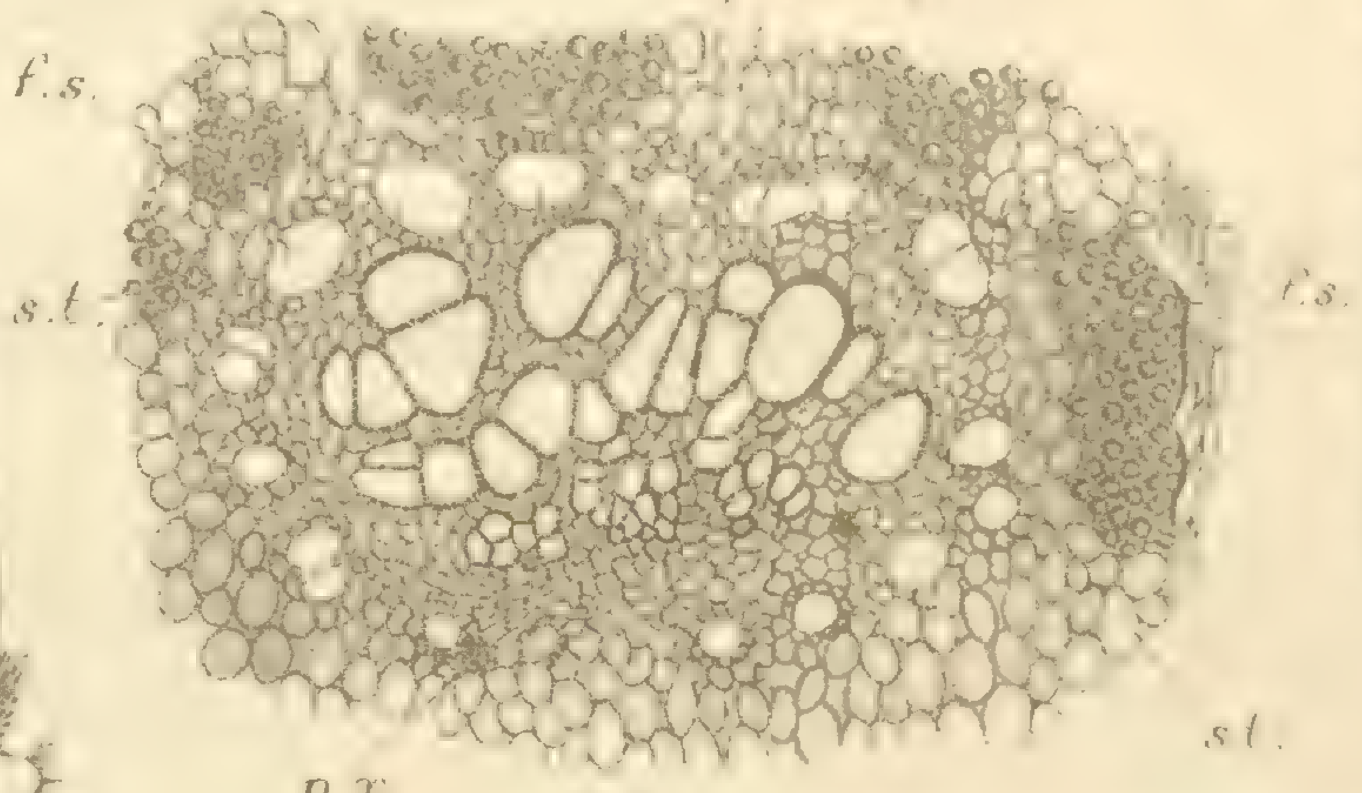
17

A. Boodle phot.

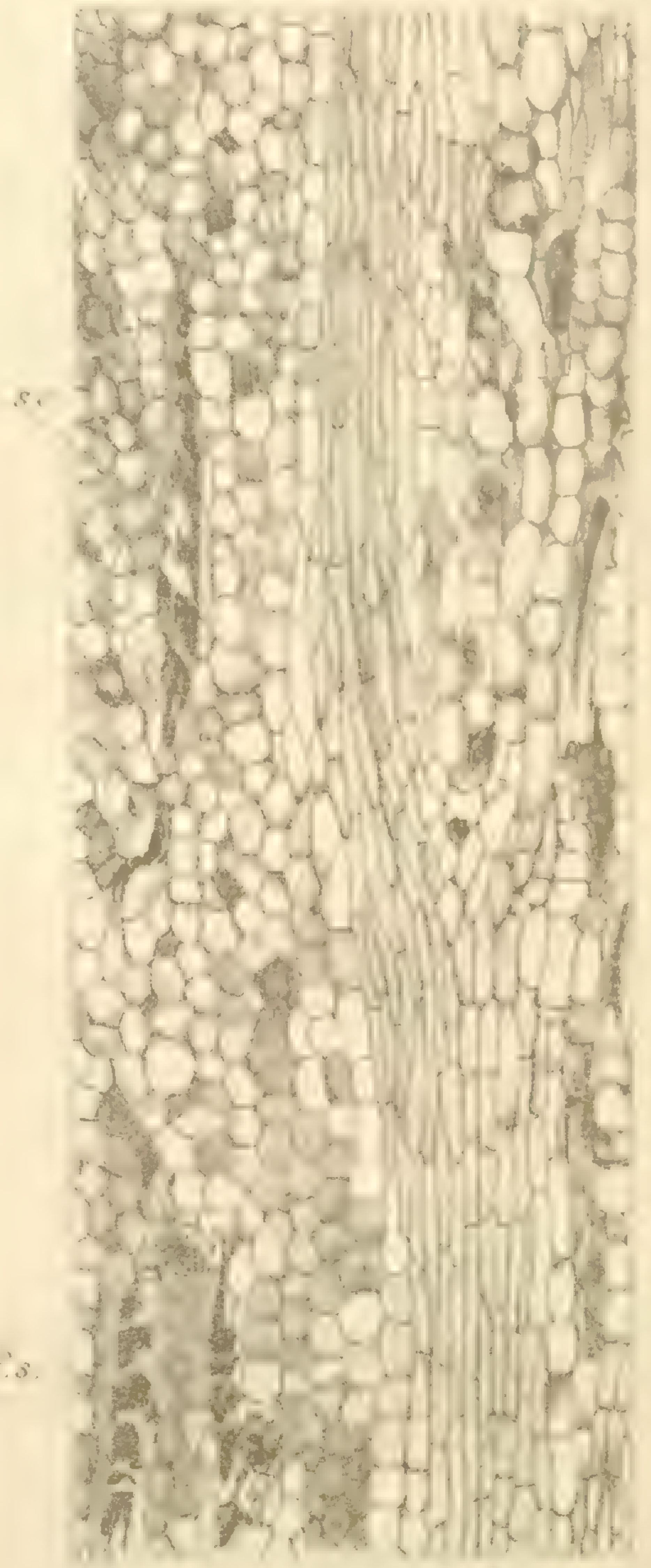
SUTCLIFFIA INSIGNIS



18.

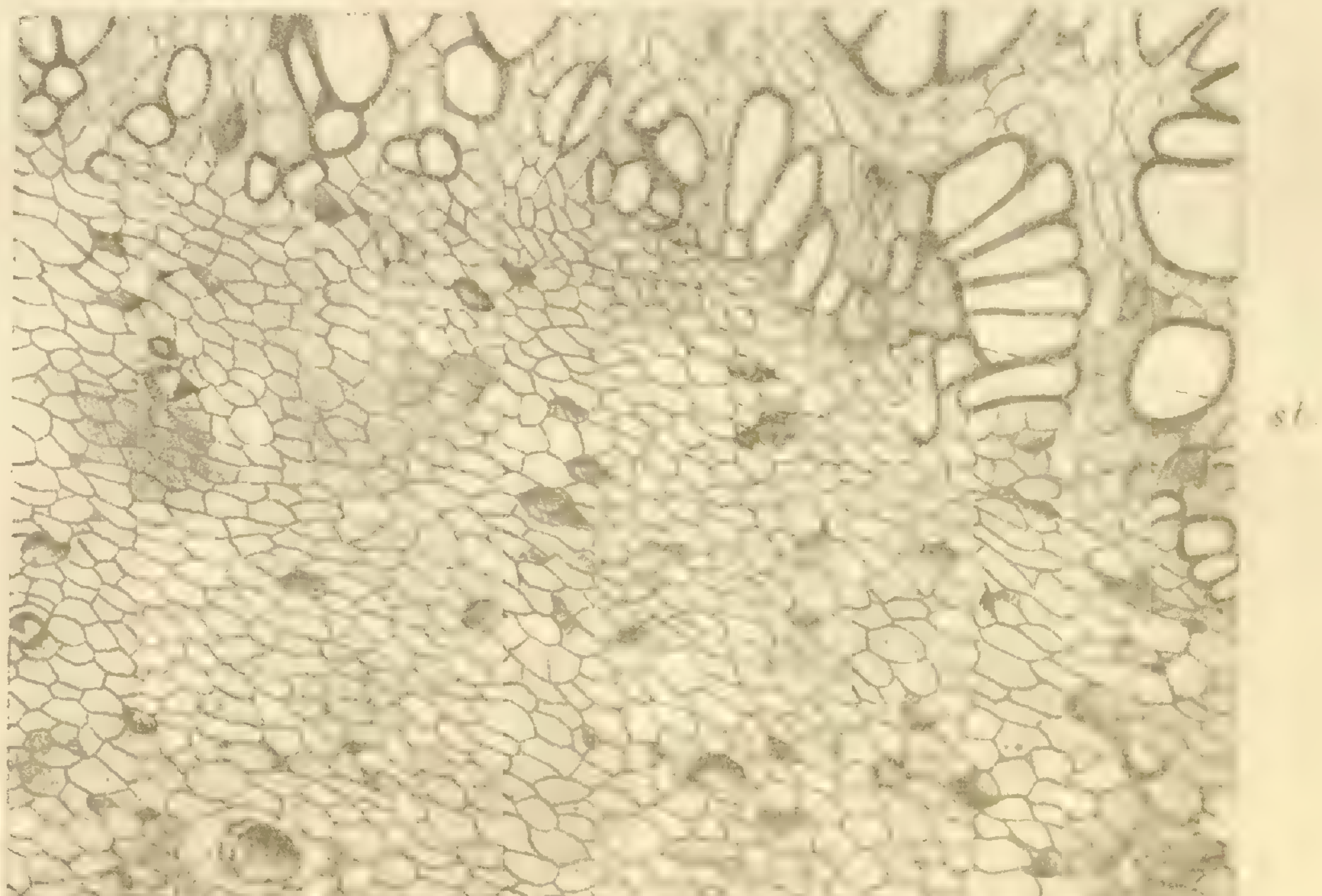


22.



20.

21.



19.

J. Allen, del. Huth, lith et imp.

SUTCLIFFIA INSIGNIS.

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s.* to the public, and 6*s.* to Fellows; to Vols. 26–30, 4*s.* to the public, and 3*s.* to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

Second Series.—Botany.

Volume.	Part	When Published.	Price to the Public. £	*s.*	*d.*	Price to Fellows. £	*s.*	*d.*
I.	Part I.	1875.	0	8	0	0	6	0
	Part II.	1875.	0	16	0	0	12	0
	Part III.	1876.	0	12	0	0	9	0
	Part IV.	1876.	0	10	0	0	7	6
	Part V.	1878.	1	4	0	0	18	0
	Part VI.	1879.	1	6	0	0	19	6
	Part VII.	1880.	1	4	0	0	18	0
	Part VIII.	1880.	1	1	0	0	16	0
	Part IX.	1880.	1	0	0	0	15	0
II.	Part I.	1881.	0	12	0	0	9	0
	Part II.	1882.	0	5	0	0	3	9
	Part III.	1883.	0	10	0	0	7	6
	Part IV.	1883.	0	3	0	0	2	3
	Part V.	1883.	0	3	0	0	2	3
	Part VI.	1884.	0	13	6	0	10	0
	Part VII.	1884.	0	9	6	0	7	0
	Part VIII.	1884.	0	10	0	0	7	6
	Part IX.	1886.	0	7	0	0	5	0
	Part X.	1887.	0	3	4	0	2	6
	Part XI.	1886.	0	6	0	0	4	6
	Part XII.	1886.	0	8	0	0	6	0
	Part XIII.	1887.	1	7	0	1	0	0
	Part XIV.	1887.	0	7	0	0	5	0
	Part XV.	1887.	0	10	0	0	7	6
	Part XVI.	1888.	0	2	6	0	2	0
III.	Part I.	1888.	3	12	0	2	14	0
	Part II.	1891.	0	5	0	0	3	9
	Part III.	1891.	0	7	0	0	5	0
	Part IV.	1891.	0	6	0	0	4	6
	Part V.	1891.	0	6	0	0	4	6
	Part VI.	1891.	0	3	6	0	2	8
	Part VII.	1892.	0	6	0	0	4	6
	Part VIII.	1893.	0	6	0	0	4	6
	Part IX.	1893.	1	8	0	1	1	0
	Part X.	1894.	0	10	6	0	7	6
	Part XI.	1894.	0	3	4	0	2	6

Second Series.—Botany (*continued*).

Volume.	Part	When Published.	Price to the Public. £	*s.*	*d.*	Price to Fellows. £	*s.*	*d.*
IV.	Part I.	1894.	1	0	0	0	15	0
	Part II.	1894.	2	0	0	1	10	0
	Part III.	1895.	2	10	0	1	17	6
	Part IV.	1895.	0	3	4	0	2	6
V.	Part I.	1895.	0	9	0	0	6	9
	Part II.	1895.	0	12	0	0	9	0
	Part III.	1896.	0	6	0	0	4	6
	Part IV.	1896.	1	0	0	0	15	0
	Part V.	1896.	0	14	0	0	10	6
	Part VI.	1896.	0	4	0	0	3	0
	Part VII.	1897.	0	4	0	0	3	0
	Part VIII.	1897.	0	6	0	0	4	6
	Part IX.	1899.	0	12	0	0	9	0
	Part X.	1899.	0	6	0	0	4	6
	Part XI.	1899.	0	7	0	0	5	0
	Part XII.	1899.	0	12	0	0	9	0
	Part XIII.	1900.	0	1	6	0	1	2
	Part XIV.	1900.	0	3	0	0	2	3
	Part XV.	1901.	0	6	0	0	4	6
VI.	Part I.	1901.	1	10	0	1	2	6
	Part II.	1901.	0	6	0	0	4	6
	Part III.	1902.	0	18	0	0	13	6
	Part IV.	1903.	0	8	0	0	6	0
	Part V.	1903.	0	8	0	0	6	0
	Part VI.	1903.	0	12	0	0	9	0
	Part VII.	1904.	0	12	0	0	9	0
	Part VIII.	1904.	0	12	0	0	9	0
	Part IX.	1904.	0	7	0	0	5	3
	Part X.	1904.	0	14	0	0	10	6
	Part XI.	1905.	0	4	0	0	3	0
VII.	Part I.	1904.	0	5	0	0	3	9
	Part II.	1905.	0	6	0	0	4	6
	Part III.	1906.	0	3	0	0	2	3
	Part IV.	1906.	0	7	0	0	5	3

2nd Ser. BOTANY.] [VOL. VII. PART 5.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

REMARKS ON THE STRUCTURE OF BAMBOO LEAVES.

BY

SIR DIETRICH BRANDIS, K.C.I.E., PH.D., F.R.S., F.L.S.

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

March 1907.

V. *Remarks on the Structure of Bamboo Leaves.*

By Sir DIETRICH BRANDIS, *K.C.I.E., Ph.D., F.R.S., F.L.S.*

(Plates 11–14.)

Read 1st November, 1906.

CONTENTS.

	Page
Introduction	69
Apparent Cavities	70
Bulliform Cells	72
Bands of Bulliform Cells in the Leaves of other Grasses	73
Chlorophyll Parenchyma	75
Midrib, Longitudinal Nerves, Transverse Veins, and Strands of Sclerenchymatous Fibres	76
Groups of large thin-walled colourless Cells	79
Epidermis	80
Structure of Leaf-sheaths	84
Distinguishing Characters of Bamboo Leaves	85
Leaf-structure: Biological and other Peculiarities of Bamboos	85
The Tribe Phareæ	87
Bibliography	88
Explanation of the Plates	89

COMMENCING with the classical researches by S. Karelstschicoff (1868) and J. Duval-Jouve (1870 and 1875) a large number of important publications on the anatomical structure of grass leaves have appeared, a list of which will be found at the end of this paper. The leaves of the tribe Bambuseæ, however, have not yet, so far as I am aware, been the subject of sufficiently comprehensive treatment. The structure of Bamboo leaves is peculiar and remarkably uniform, and this I regard as the principal result of my present researches. These researches, however, in no way exhaust the subject. Though I have examined the leaves of 122 species belonging to 21 genera, I must here content myself with describing certain general features and must leave many important points to be settled by the researches of younger botanists.

The transverse section of a mature Bamboo leaf shows halfway between two longitudinal nerves a band of remarkable bulliform cells belonging to the upper epidermis, first figured by Karelstschicoff, in Bull. Soc. Nat. Mosc. xli. t. 3. fig. 1, for *Bambusa stricta* (*Dendrocalamus strictus*, Nees), and fully described as "cellules bulliformes" for numerous species of grasses by Duval-Jouve. On both sides of this band, between it and the vascular bundles (longitudinal nerves) in the interior of the leaf, but nearer the lower epidermis, are large, more or less oblong, apparent cavities, the nature of which has been correctly explained by Karelstschicoff. The remaining space between two

longitudinal nerves and the lower and upper epidermis is, as a rule, filled up by thin walled chlorophyll-cells, the walls of these cells being folded in a peculiar manner. Strands of sclerenchymatous fibres support the vascular bundles, and with them constitute the longitudinal nerves. There is always an upper and a lower strand between the vascular bundle and epidermis. In Bamboos I have never found continuous bands of stereome under the epidermis, and in one instance only have I found strands of sclerenchymatous fibres below the bulliform cells under the lower epidermis. (The instance here referred to is a Bamboo cultivated at Kew as *Ochlandra Rheedii*. Leaves of *O. Rheedii*, Benth., collected in Cochin and Travancore, have no stereome below the bulliform cells.) In other grasses they are not uncommon: *Aira cæspitosa*, Lewton-Brain, in Trans. Linn. Soc. ser. 2, vol. vi. (1903) t. 40. fig. 67; *Agrostis canina*, ibid. t. 37. fig. 19; *Alopecurus geniculatus*, *A. alpinus*, ibid. t. 37. figs. 21, 25.

I may here mention that the author of each species is, as a rule, given only once, when that species is mentioned for the first time. Writers on anatomical subjects often omit the authority for a species, so that it is sometimes uncertain which species is intended. In such cases I have not been able to supply the deficiency.

These studies I commenced at Bonn in 1887, and have had the great privilege of completing them at the Jodrell Laboratory of the Royal Botanic Gardens, Kew, with the aid of the excellent library of the Herbarium. I tender my thanks to Mr. L. A. Boodle, F.L.S., for the valuable help and advice he has most kindly given me, and to Professor Strasburger and Dr. Scott for many important suggestions; to Mr. J. N. Fitch for the excellent drawings he has made from my preparations, and to Mr. Martin Cole for the admirable sections which he prepared.

Apparent Cavities.

As explained by Karelstschicoff, (3) t. 3. fig. 2 (*Dendrocalamus strictus*, Nees), the apparent cavities mentioned above are entirely occupied by a large number of flat thin-walled cells, lying upon each other like the leaves of a book. They are, as a rule, filled with a colourless sap and the walls show with chlor-zinc-iodine the reaction of cellulose. Only in *Dinochloa Macclellandii*, Kurz, among Bamboos have I found solid contents of organic matter, but the study of the dried specimens at my disposal has not enabled me to say anything further. *Diandrolyra bicolor*, Stapf, among Phareæ has chlorophyll in the thin-walled cells which fill the apparent cavities. The structure of these flat thin-walled cells is best studied in thin longitudinal sections. Plate 12. fig. 17 represents a small piece of a very young leaf, rolled up in bud, of *Dendrocalamus giganteus*, Munro, grown in the Palm-house at Kew; the cells are turgescent. In an older state, often before the leaves are fully flattened out, the walls collapse and hang between the upper and lower strata of chlorophyll parenchyma, and may be compared to empty bags of the finest muslin. This is the stage represented by Karelstschicoff, and that which is seen whenever longitudinal sections of full-grown Bamboo leaves are made. This stage is here represented in *Arundinaria japonica* (Pl. 11. fig. 3), *Phyllostachys bambusoides*, Sieb. et Zucc. (Pl. 11. fig. 8), and *Dinochloa andamanica*, Kurz (Pl. 13. fig. 24). These

flat thin-walled cells can readily be isolated by boiling in diluted nitric acid with potassium chlorate. Karelstschicoff, (3) t. 3. fig. 3 (*a*), shows them in *Dendrocalamus strictus*, and on Pl. **14.** figs. 40–43 of the present paper they are represented in *Sasa paniculata*, Makino & Shibata, in 'Tokyo Botanical Magazine,' xv. (1901) p. 25 (=*Arundinaria Kumasasa*, Hort. Kew); *Cephalostachyum capitatum*, Munro; *Melocanna bambusoides*, Trinius; and *Ochlandra Beddomei*, Gamble. They are exceedingly uniform in appearance, the sharp points on the outside of the walls indicate the points inserted between the cells of the mesophyll and between the indentations of the cells constituting the parenchyma-sheath of the vascular bundle.

These flat thin-walled cells may also be studied on flat sections made parallel with the surface of the leaf, as represented in Pl. **14.** fig. 35 for *Melocanna bambusoides*, the section passing through the longitudinal nerves and the chlorophyll-tissue, which separates two apparent cavities and which is situated below the bulliform cells. In pieces of Bamboo leaves boiled in water and afterwards placed in glycerine, the flat thin-walled cells appear under the microscope as distinct transverse lines (*Melocanna bambusoides*, Pl. **13.** fig. 26). They are conspicuous when the leaf has been kept in a concentrated solution of phenol, Pl. **11.** fig. 1 (*Arundinaria falcata*, Nees) and Pl. **13.** fig. 27 (*Melocanna bambusoides*). They have been omitted in the drawing of *Cephalostachyum pallidum*, Munro, Pl. **13.** fig. 21, so as not to confuse the picture.

The transverse section of a bud of *Arundinaria japonica*, Sieb. et Zucc. (Pl. **11.** fig. 2), shows that at an early stage, when the epidermis and vascular bundles have been formed, but long before the bulliform cells of the upper epidermis have developed, the tissue of the mesophyll is gradually differentiated, with the result that the apparent cavities appear. The earliest development of the flat thin-walled cells filling up these cavities will doubtless form the subject of an interesting histological study, which I must leave to younger heads.

It is a remarkable fact that in a transverse section the apparent cavities here described have the appearance of being empty, although, even in the thinnest section, there must be several layers of these thin-walled cells, either (in the case of a very young leaf) turgescent or (in the case of older leaves, when the walls have collapsed) separated by wide intercellular spaces, probably filled with air, which, however, is readily absorbed by the fluid in which the section is mounted under the microscope. The explanation of this remarkable appearance I must leave to others. It may be useful to mention that chlor-zinc-iodine gives these apparent cavities in transverse sections a very faint bluish tinge, and that in longitudinal sections the walls of the flat thin-walled cells are exceedingly bright under the polariscope.

From what has been here stated it will be understood that the tissue of flat thin-walled cells here described, which fills the apparent cavities in Bamboo leaves, has a structure entirely different from the tissue of short-armed cells which in young leaves of *Glyceria aquatica* and other aquatic grasses fills the air-spaces between the longitudinal nerves (Duval-Jouve, 'Agropyrum,' t. 16. fig. 13).

The apparent cavities here described are fairly uniform in size in a transverse section

in full-grown leaves of any one species. In some species, however, they are much narrower than in others ; instances are *Phyllostachys mitis*, Rivière, and *Dendrocalamus strictus*, Nees. And I have found a remarkable case of abnormal structure in specimens of *Melocanna bambusoides*: the leaf is dwarfed, the space between longitudinal nerves much reduced, and the apparent cavities small, the two sometimes confluent into one.

Bulliform Cells.

It will be convenient to commence the study of the bulliform cells at an early stage of their development. Pl. 12. fig. 17 represents the youngest leaf of *Dendrocalamus giganteus*, Munro, rolled up in bud. What may perhaps first of all attract the attention of the reader is a matter of no importance, which we had better dispose of at once. The lower (in the rolled-up leaf, outer) epidermis is uneven with protuberances and hairs. This is a general character of all Bamboos. But in the present case there are also hairs on the upper epidermis. These, however, are only there in the youngest state; afterwards, as the leaf matures, they dry up and fall away. The upper epidermis of mature leaves in Bamboos, with a few exceptions, is quite smooth. The vascular bundles (longitudinal nerves) are fully developed, so are the apparent cavities and the cells of the chlorophyll-containing tissue, as well as the upper and lower epidermis : the bulliform cells, however, are scarcely beginning to be differentiated from the other cells of the upper epidermis ; they are indicated by a longitudinal furrow. A section of a leaf a little older is represented on Pl. 12. fig. 16. Here the bulliform cells begin to show, but they are still situated in a longitudinal furrow. At a later stage, when the leaf is flattened out, they increase in size and are raised above the surface of the epidermis, figs. 12, 13, 14. A similar development in the case of *Melocanna bambusoides* is represented in Pl. 13. figs. 29, 30, and Pl. 14. fig. 31.

The leaves of all Bamboos, so far as known to me, have vernatio convoluta, that is, the leaf is rolled up in bud and afterwards spreads out flat. *Chusquea pinifolia*, Nees (Pl. 14. fig. 39), may possibly be an exception. As clearly explained by Duval-Jouve ('Histotaxie des feuilles de Graminées,' p. 322), the spreading out flat of grass leaves with convolute vernation is greatly facilitated by the development of the bulliform cells. Tschirch (1882) ascribes to the same cells certain other functions in connection with the rolling up of the leaves of some species, when the plant is dry ('Jahrbücher für wissenschaftliche Botanik,' xiii. p. 544), and he gives them the name of Gelenkzellen or Gelenkpolster (link-cells). In this he is followed by Güntz (1886), p. 16, and by Raunkiær (1895–1899), who calls them Ledcellerne. Volkens (1887), Fl. Aegypt.-Arab. Wüste, p. 55, describes the leaves of *Cynodon Dactylon* and other species, which have, in continuation of the bulliform cells of the upper epidermis, a tissue of thin-walled colourless cells separating the rings of chlorophyll parenchyma that surrouud the longitudinal nerves. When leaves of this description are dry they shrivel up, because the transverse bands of colourless cells collapse. When supplied with water they resume their former turgescence. Accordingly Volkens regards these bands of colourless thin-walled tissue, consisting partly of bulliform cells, as water-cells (Wasserzellen).

Pée-Laby, in Ann. des Sc. Nat. 8me sér. (1898), viii. p. 314, calls the cells of the upper epidermis, described as cellules bulliformes by Duval-Jouve, cellules motrices; Marshall Ward (1901) and Lewton-Brain (1903) call them motor-cells. Hackel (1882) and Theodore Holm (1891–1896) retain the name given by Duval-Jouve, and following these authors I shall speak of them as bulliform cells.

In Bamboos, although their development certainly enables the young rolled-up leaf to spread out flat, these cells when mature, in a large number of species, become filled with solid silica entirely or partially. The effect is to make the blade of the mature Bamboo leaf rigid and not motile. This remarkable fact induced me when I first discovered it, several years ago, to call them silica-cells, which term I adopted on p. 661 of my 'Indian Trees.' Since that time, however, I have found so many species with few only of these epidermis-cells filled with silica, that I now prefer the designation bulliform cells.

These silica-bodies are colourless; when calcinated they remain unchanged, and they are not affected by nitric acid. They are not crystalline; under the polariscope they have the appearance of opal. They can readily be distinguished in a piece of leaf that has been boiled in water and has afterwards been placed in a concentrated solution of phenol (10 parts of water to 100 parts of crystallized phenol). In some species (*Cephalostachyum*, Pl. **13.** fig. 21, *Ochlandra*) nearly all the bulliform cells are filled with silica, in others (*Arundinaria falcata*, Pl. **11.** fig. 1; *Melocanna bambusoides*, Pl. **13.** fig. 27) about one-half of the cells are empty, and in some species (*Dendrocalamus giganteus*, Munro, and *D. Brandisii*, Kurz) the silica-bodies are scanty and at times entirely absent.

Young leaves while rolled up have no silica-bodies in the bulliform cells, and it will be a matter of considerable interest to study the history of their development as the leaf matures. The walls of the bulliform cells as a rule are thin, and with chlor-zinc-iodine show the reaction of cellulose. In some cases the outer wall is thick; the substance of the thickening requires further enquiry. Longitudinal sections of leaves, passing through the band of bulliform cells, are represented in Pl. **11.** fig. 10, *Bambusa vulgaris*, Schrader, and Pl. **13.** fig. 25, *Dinochlora andamanica*, Kurz.

Bands of Bulliform Cells in the Leaves of other Grasses.

A large number, perhaps the majority, of Grasses have, like Bamboos, bands of bulliform cells alternating with the longitudinal nerves on the upper epidermis only. There are, however, other modes in which these remarkable cells are distributed, and it may be useful briefly to review them, following in the main points the classification established by Duval-Jouve ('Histotaxie,' p. 318).

A. Bands of bulliform cells in the upper epidermis only.
 a. Alternating with longitudinal nerves.
  I. Paniceæ. *Panicum* (partly), *Pennisetum* (partly), *Spartina.*
  III. Oryzeæ. *Oryza.*
  V. Zoysieæ. *Tragus.*
  VI. Andropogoneæ. *Saccharum, Elionurus, Andropogon.*
  VII. Phalarideæ. *Phalaris* (incl. *Digraphis*) (partly), *Hierochloa, Crypsis, Alopecurus.*

VIII. Agrostideæ. *Aristida, Stipa* (partly), *Oryzopsis* (incl. *Piptatherum*), *Milium, Phleum, Sporobolus, Agrostis, Polypogon, Calamagrostis, Ammophila* (incl. *Psamma*), *Lagurus.*

IX. Aveneæ. *Aira* (partly), *Holcus, Trisetum, Avena* (partly), *Gaudinia.*

X. Chlorideæ. *Ctenium, Chloris* (partly), *Eleusine* (partly).

XI. Festuceæ. *Pappophorum, Triodia, Diplachne, Gynerium, Arundo, Phragmites, Cynosurus, Koeleria, Molinia, Eragrostis, Melica* (partly), *Uniola, Æluropus, Briza, Poa* (partly), *Glyceria* (partly), *Festuca* (partly), *Bromus, Brachypodium.*

XII. Hordeæ. *Lolium, Agropyrum, Triticum, Lepturus, Hordeum, Elymus.*

XIII. Phareæ, Stapf. *Olyra, Diandrolyra, Pharus, Leptaspis.*

XIV. Bambuseæ. All species.

b. Alternating with stouter and over slender nerves.

I. Paniceæ. *Panicum* (partly), *Setaria, Cenchrus* (partly), *Pennisetum* (partly).

II. Maydeæ. *Coix, Tripsacum, Zea.*

VI. Andropogoneæ. *Imperata, Saccharum* (partly), *Erianthus, Andropogon* (partly), *Sorghum.*

c. One band on each side of midrib and a few near edge of leaf.

VI. Andropogoneæ. *Andropogon* (partly).

d. One band on each side of midrib only.

VI. Andropogoneæ. *Andropogon* (partly).

IX. Aveneæ. *Aira* (partly), *Avena* (partly).

X. Chlorideæ. *Eleusine* (partly).

XI. Festuceæ. *Sesleria, Catabrosa, Pleuropogon, Poa* (partly), *Glyceria* (partly).

XII. Hordeæ. *Nardus.*

e. One band over midrib, with or without lateral bands.

VI. Andropogoneæ. *Andropogon* (partly).

X. Chlorideæ. *Chloris* (partly), *Eleusine* (partly).

XI. Festuceæ. *Dactylis.*

B. Bands of bulliform cells both in lower and upper epidermis.

I. Paniceæ. *Amphicarpum, Panicum* (partly), *Cenchrus* (partly).

III. Oryzeæ. *Leersia.*

VII. Phalarideæ. *Phalaris* (partly).

IX. Aveneæ. *Danthonia.*

XI. Festuceæ. *Melica* (partly).

C. No distinct bands of bulliform cells.

VIII. Agrostideæ. *Stipa* (partly), *Mibora* (*Chamægrostis*).

XI. Festuceæ. *Ampelodesma, Distichlis, Festuca* (partly).

It is a noteworthy fact that in all Bamboos and the genera of the new tribe Phareæ the distribution of bulliform cells is uniform; for among the genera for which the structure of leaves has been recorded no less than 13 have a different arrangement in some of their species. These genera are, arranged according to tribes in their usual sequence:—I. *Panicum, Cenchrus, Pennisetum.* VI. *Andropogon.* VII. *Phalaris.* VIII. *Stipa.* IX. *Aira, Avena.* X. *Eleusine.* XI. *Melica, Poa, Glyceria, Festuca.* The only case analogous to that of Bamboos in this respect is that the three genera of Maydeæ (*Coix, Tripsacum,* and *Zea*), of which the leaves have been examined, have the bands of bulliform cells alternating with the stouter, and situated over the slender nerves.

Chlorophyll Parenchyma.

In Bamboos the chlorophyll parenchyma forms a continuous tissue, filling up the space between the longitudinal nerves, the upper and lower epidermis, and the apparent cavities. Many genera of other tribes (Paniceæ, Maydeæ, Zoysieæ, Andropogoneæ, Phalarideæ, Agrostideæ, Chlorideæ, and Festuceæ) have the chlorophyll parenchyma arranged in distinct cylinders, surrounding the longitudinal nerves, the chlorophyll-cells outside the parenchyma-sheath of the vascular bundle standing at right angles to the surface of that sheath and appearing in a transverse section as palisades radiating in all directions. This arrangement, which is described by Duval-Jouve ('Histotaxie,' p. 348) and by Pée-Laby (in Ann. Sc. Nat. 8me sér. viii. 1898, p. 287), has not yet been found among Bamboos.

Between the apparent cavity and the upper epidermis we usually find two or three horizontal layers of cells, while below, between its lower edge and the lower epidermis, there is, as a rule, one layer only. Sometimes two are found (*Dinochloa andamanica* and *Dendrocalamus giganteus*). This character varies in the same species. Below the bulliform cells and between the two apparent cavities there are three or four horizontal layers of cells, filling up the space above the lower epidermis. One of these layers, consisting of from one to three cells, separates the two apparent cavities. When this layer consists of one cell only it is often empty, and its walls are plain, without folds (Pl. 12. fig. 13, *Dendrocalamus giganteus*). Both arrangements, two or three cells with folded walls and full of chlorophyll and a single empty cell with plain walls, I have found in the same leaf.

The chlorophyll-cells of Bamboos as a rule have the shape of flat, irregularly oblong plates with rounded edges—the broad face, which shows in a transverse section, being vertical, at right angles to the surface of the leaf, while of the two narrow faces the shorter is seen in a longitudinal section and the longer in a flat section, cut parallel with the surface of the leaf. Both broad faces have a number of projecting rounded folds which divide each cell into a number of tubular compartments. In many cells these folds are continuous from top to bottom, in others they do not reach to the middle. These folds were figured and fully explained by Karelstschicoff on p. 183 of his paper (3) and in fig. 3 (*b*, *c*, *d*) of his t. 3. In the cells between the apparent cavities and the lower epidermis the folds proceed from the upper edge only, while in the cells immediately under the upper epidermis the folds proceed from the lower edge. In the other cells the folds proceed from both edges, and in the cells between the lower epidermis and the bulliform cells they project into the interior from all four sides. Wendehake, on page 54 of his paper ("Anatomische Untersuchungen einiger Bambuseen"), states that, while all species of *Arundinaria* and *Phyllostachys* examined by him have folds proceeding from the upper and lower edge in the cells immediately above the apparent cavity, two Bamboos (*Bambusa vulgaris*, Nees, and *B. verticillata*, Nees) have folds on the lower edge only in these cells. It is not clear to which species the author refers: *Bambusa vulgaris*, Schrader, is a well-known species, but there is no *B. vulgaris*,

Nees. *Bambusa verticillata*, Willd., is a synonym of *Gigantochloa verticillata*, Munro, but there is no *Bambusa verticillata*, Nees.

Among the numerous species of which I have examined transverse sections, *Melocanna bambusoides* (Pl. 13. fig. 30 and Pl. 14. fig. 31) is the only one which in the intermediate cells has folds from the lower edge only. For purposes of classification I am not disposed to attach any importance to this character.

The cells of the chlorophyll parenchyma are arranged in horizontal lines parallel to the surface of the leaf and they are separated by intercellular spaces. Pl. 11. fig. 5 represents a flat section showing the tissue below the upper epidermis of *Arundinaria Hookeriana*, Munro, between a longitudinal nerve and the lower portion of the bulliform cells, while Pl. 14. fig. 35 represents the tissue separating the apparent cavities, in a flat section made near and parallel to the lower epidermis of *Melocanna bambusoides*. It will be noticed that the chlorophyll-cells, which a transverse section shows as oblong plates, in these horizontal sections appear oblong with rounded ends with prominent circular markings caused by the tubular folds proceeding from the upper and lower edge of these cells. As already stated, this remarkable appearance of the chlorophyll-cells of Bamboos was clearly explained by Karelstschicoff in 1868.

Midrib, Longitudinal Nerves, Transverse Veins, and Strands of Sclerenchymatous Fibres.

The structure of the longitudinal nerves in Grasses has been fully described by previous authors. With very few exceptions the leaves of Bamboos have a distinct midrib, though in many species (e. g. *Melocanna bambusoides*) the midrib gets very thin towards the apex and sometimes cannot be distinguished from the lateral nerves. On both sides of the midrib there are generally two classes of longitudinal nerves, stout or coarse, and between each pair of these a varying number of fine or slender nerves. The former Ettingshausen designates as Seitennerven, Gamble as Secondary Nerves, while the thin nerves are called Zwischennerven by the former and Intermediate Nerves by the latter author. Each nerve consists of two portions, a vascular bundle and two girders of sclerenchymatous fibres, one above, the other below the vascular bundle. The lower girder frequently is extended upwards, so as partially to enclose the vascular bundle (*Sasa paniculata*, *Bambusa vulgaris*, *Dinochloa andamanica*). The stout nerves always have from two to four large vessels, in the slender nerves the vessels are much smaller.

The vascular bundles in the longitudinal nerves of Bamboos are enclosed in a sheath which consists of two portions. The outer portion ("Parenchym-Scheide," Schwendener) consists of one layer of large elongated parenchymatous cells with square ends, which contain starch and frequently chlorophyll. In a transverse section this sheath appears as a ring of orbicular cells, the walls of which, as a rule but not always, show the reaction of cellulose. In some cases, chiefly on the underside, where the lower strand of sclerenchymatous fibres is enlarged, this ring is frequently interrupted. The transverse

section of the parenchyma-sheath is shown on Pl. 11. fig. 7 (*Phyllostachys*); fig. 12; Pl. 12. figs. 13, 14, 16, 17 (*Dendrocalamus*); Pl. 13. fig. 23 (*Dinochloa*); figs. 29, 30; Pl. 14. fig. 31 (*Melocanna*) and fig. 39 (*Chusquea*); while the longitudinal section appears from Pl. 11. fig. 5 (*Arundinaria Hookeriana*) and Pl. 14. fig. 35 (*Melocanna*). The inner sheath ("Mestomscheide," Schwendener), which is wanting in many Grasses, is always present in Bamboos. Like the parenchyma-sheath it consists of elongated cells, the end-walls of which are either square or pointed. The walls are thick and I have always found them strongly lignified; they are pitted like those of the sclerenchymatous fibres. This inner sheath often consists of several layers of cells.

In Bamboos the number of slender or intermediate nerves between two stout nerves varies from 1 to 10, the usual number being 5 to 8. In most species the two classes can readily be distinguished, but there are exceptions. Ettingshausen (p. 5) has made an attempt to classify grasses according to the greater or less distance between intermediate nerves (Zwischennerven). For the classification of all species this character is hardly suitable, but in some cases the distance between longitudinal nerves will be found useful to facilitate the identification of species when leaves only are available. I find it convenient to count the number of nerves, secondary and intermediate, in a quarter of an inch. Only full-grown leaves should be selected and the nerves must be counted in the middle, halfway between base and tip. They are often closer together near the edge of the leaf, hence an average should be struck between countings near the edge and the midrib. Leaves grown under exceptional circumstances, for instance in a hothouse, are apt to be irregular and should be avoided. As the leaf gets narrower towards the tip, a number of nerves disappear, and though it is safer to count in the middle, the distance between the nerves remains very much the same.

The point which I desire here to make clear is, that in some species the longitudinal nerves are further apart than in others. My description of Bamboos in my 'Indian Trees' gives the mean distance for the different species. The following list of some of the more noteworthy species may seem to illustrate what has been stated:—

Species.	Width of leaf in the middle (in inches).	Nerves in $\frac{1}{4}$ inch.
Arundinaria falcata, Nees	$\frac{1}{4}$–$\frac{1}{3}$	36–45
A. Hookeriana, Munro	$\frac{1}{2}$–$1\frac{1}{2}$	21–24
A. spathiflora, Trinius	$\frac{1}{3}$–$\frac{1}{2}$	24–30
A. Falconeri, Benth. & Hook. f.	$\frac{1}{4}$–$\frac{3}{4}$	21–27
A. jaunsarensis, Gamble	$\frac{1}{2}$–$\frac{2}{3}$	33–42
Bambusa Tulda, Roxb.	1	30–43
B. khasiana, Munro	1–$1\frac{1}{2}$	18–21
B. Balcooa, Roxb.	1–2	21–30
B. arundinacea, Willd.	$\frac{3}{4}$	30–45
Dendrocalamus longispathus, Kurz	1	25–30
D. giganteus, Munro	2–4	20–28
Teinostachyum Wightii, Bedd.	1–3	16–20
Melocanna bambusoides, Trinius	1–4	18–24

As might be expected, the nerves are further apart in broader leaves, but besides the width of leaf the individuality of each species is also well marked.

A Bamboo without a midrib is *Chusquea pinifolia*, Nees (Pl. 14. fig. 39), which inhabits the mountains of South-east Brazil between 3000 and 6000 feet. The leaves are narrow and have, as a rule, three stouter and, alternating with them, four thinner nerves. As already mentioned, this species is anomalous, as it has no apparent cavities. The bands of bulliform cells in the upper epidermis, however, in this as in all other Bamboos, alternate with the longitudinal nerves; each vascular bundle is supported by two girders of sclerenchymatous fibres, but the intervening chlorophyll parenchyma is continuous, not interrupted by apparent cavities.

The midrib always contains several vascular bundles, arranged in two horizontal lines, one below the upper, the other above the lower epidermis, each bundle adjoining or enclosed in the girders of sclerenchymatous fibres, which are immediately under the epidermis. The two lines of vascular bundles are, with rare exceptions, separated by a broad, rarely narrow, band of large cells. These, like the cells of the parenchyma-sheath, which enclose the longitudinal nerves, frequently contain starch. This tissue, as a rule, has intercellular spaces and the walls are often lignified. When this band is narrow it widens out to the right and left (Pl. 12. fig. 19, *Dendrocalamus strictus*). In most cases there are 2 to 6 vascular bundles below the upper and 1 to 4 above the lower epidermis. There are, however, exceptions: thus *Dendrocalamus strictus* has only one vascular bundle above and one below, and *Dendrocalamus Hamiltonii* (Pl. 12. fig. 20) has 6 in the upper and 18 to 20 in the lower line. These figures relate to the middle of the leaf halfway between base and apex. As may be expected, the midrib has not the same structure throughout the length of the leaf. This is illustrated by Pl. 14. figs. 32–34, representing transverse sections of the midrib of *Melocanna bambusoides* at the base, in the middle, and below the apex of the leaf. It will be noticed that the number of vascular bundles above the lower epidermis diminishes from 4 to 1, while below the upper epidermis there are 4 at the base and in the middle, and 3 near the apex. In this species some of the upper vascular bundles show an inverted orientation, the phloem being lateral and in some cases situated on the upperside of the xylem. The vascular bundles scattered in the pith of the rhachis of *Simaba glandulifera* (C. De Candolle, 'Anatomie comparée des feuilles,' t. 1. fig. 15) seem to show a similar irregularity in orientation.

In some cases the vascular bundles of the midrib are enclosed in the belts of sclerenchymatous fibres mentioned above. Instances are *Arundinaria Falconeri* and *Melocanna bambusoides*, in the middle of the leaf (Pl. 14. fig. 33). In these cases the two belts of sclerenchymatous fibres have united and the vascular bundles of the midrib are imbedded in a mass of sclerenchymatous fibres. The vascular bundles of the midrib have not, as a rule, a separate parenchyma-sheath, and it may, I suppose, be assumed that the tissue of large cells in the midrib, previously adverted to, has the function of a parenchyma-sheath.

It has long been known that all Bamboos, like other Grasses, have transverse veins in

their leaves. Karelstschicoff (p. 181) mentions them and so does Duval-Jouve ('Histotaxie,' pp. 306, 307). Max Güntz (p. 49) describes their structure, and Marshall Ward ('Grasses,' p. 68) states that, contrary to the general assumption, there are frequent though minute transverse bundles joining the parallel veins. In many systematic works the species of Bamboos are classified into those with transverse veins (*Phyllostachys*, most species of *Arundinaria*) and those without them. The fact is, that in the leaves of the second class the transverse veins are obscured by the chlorophyll parenchyma. They can, however, in all cases be made conspicuous by bleaching reagents or by scraping away part of the tissue. The following figures show the transverse veins in longitudinal sections: Pl. 11. fig. 3, *Arundinaria japonica*; Pl. 13. fig. 25, *Dinochloa andamanica*; and Pl. 12. fig. 18, *Dendrocalamus giganteus*. In transverse sections of other grasses the veins are shown in Duval-Jouve ('Histotaxie,' tab. 17. fig. 11, *Stipa altaica*, and tab. 19. fig. 6, *Aira latifolia*). Regarding the anatomical structure of these transverse veins I am not quite clear, and would recommend the subject to the attention of younger botanists. Güntz (p. 49) quotes a paper by Alfred Koch (Strasburg, 1884), according to which they mostly consist of tracheids. In the midribs transverse veinlets frequently anastomose between vascular bundles.

The bands or girders of sclerenchymatous fibres which, with the vascular bundles, constitute the longitudinal nerves and those which occupy a large portion of the midrib have already been noticed; it remains to mention those which we find in the margin of Bamboo leaves. Here, along the margin, there is always a colourless band, the edge of which bears a line of thick-walled pointed hairs or (on the inner margin of the leaves of *Melocanna bambusoides*) a large number of closely-set slender hairs. This colourless band under the epidermis consists entirely of thick-walled sclerenchymatous fibres (Pl. 12. fig. 14, *Dendrocalamus giganteus*). It has already been stated that Bamboos, as a rule, have no girders of sclerenchymatous fibres above the lower epidermis under the bulliform cells.

The leaves of Bamboos, like those of most other Grasses, owe their toughness mainly to the numerous girders of sclerenchymatous fibres which run under the epidermis through the entire length of the leaf. When a leaf is macerated in nitric acid and potassium chlorate, these fibres constitute a large portion of the mass of isolated elements. They are very gradually narrowed into sharp pointed ends, and the walls of the larger ones are distinctly pitted. Their length varies from 0·6 to 1 mm.

Groups of large thin-walled colourless Cells.

Under the heading "Parenchyme simple incolor," Duval-Jouve includes what has here been called the parenchyma-sheath of vascular bundles, as well as the tissue of large cells frequently containing starch, which forms part of the midrib. Besides these, which have been discussed in the last section, we find in many species, generally on both sides of the midrib, groups of large thin-walled cells, without intercellular spaces and without any apparent contents: *Dendrocalamus strictus* (Pl. 12. fig. 19), *D. Hamiltonii*

(Pl. 12. fig. 20). Groups of similar cells are often found near the edge of the leaf between the band of sclerenchymatous fibres and the first longitudinal nerve: *Dendrocalamus giganteus* (Pl. 12. fig. 14). Here and on both sides of the midrib these masses of thin-walled colourless cells occupy the place of the apparent cavities: *Dendrocalamus strictus* (Pl. 12. fig. 19). The idea that there is some analogy between these two tissues would seem to be supported by the fact that on a transverse section the apparent cavities in some cases appear to consist of cells other than the flat thin-walled cells described above.

Volkens, in his important work 'Die Flora der Aegyptisch-Arabischen Wüste,' describes a tissue of thin-walled colourless cells peculiar to those species which have the chlorophyll parenchyma arranged in rings around the vascular bundles (*Panicum turgidum*, *Pennisetum dichotomum*, *Sporobolus spicatus*, *Cynodon Dactylon*, and *Eragrostis cynosuroides*). These thin-walled colourless cells, which are a continuation of the bulliform cells of the upper epidermis and which separate the cylinders of chlorophyll parenchyma, Volkens correctly designates as water-cells. A tissue of this character I have not been able to find in Bamboos, but it seems possible that the groups of thin-walled cells here described, as well as the flat thin-walled cells which fill the apparent cavities, may, under certain circumstances, serve for the storage of water.

Epidermis.

The epidermis of Bamboo leaves is remarkably uniform. Apart from the bulliform cells of the upper, both the upper and lower epidermis consist of two classes: firstly, elongated, usually linear cells, the walls of which are strongly undulated; secondly, short cells, single or in pairs, which alternate with the elongated cells. I have not found any Bamboos with the walls of the long epidermis-cells in straight lines, such as are often found in other Grasses, e. g. *Pleuropogon*, Holm, in Bot. Gaz. xvi. (1891) t. 24. fig. 9. The short cells ("Kurzzellen," Grob; "Zwergzellen," Güntz) are more or less transversely rectangular, the ends generally rounded. Of the numerous other shapes described by Grob, I have only found those which he calls Saddle-cells. In the bands which lie over the sclerenchymatous fibres the short cells are frequently larger (Pl. 11. fig. 9, *Bambusa vulgaris*). Of both the upper and lower epidermis-cells the outer wall is considerably thicker than the side-walls, and on the lower epidermis there are, as a rule, numerous mostly solid protuberances of the outer wall (blunt, fig. 15, *Dendrocalamus Hamiltonii*; pointed, fig. 7, *Phyllostachys bambusoides*), which on a surface view appear as circles (Pl. 12. fig. 28, *Melocanna bambusoides*). There are hairs of several kinds, mostly on the lower, rarely on the upper surface. The principal kinds are short hairs, blunt or pointed (Pl. 12. figs. 13, 14, 15, 18, *Dendrocalamus giganteus*); long stiff hairs (Pl. 11. fig. 7, *Phyllostachys bambusoides*); blunt soft pluricellular hairs, the upper cells of which generally have the walls collapsed (Pl. 13. fig. 28, *Melocanna bambusoides*); finally, long soft hairs (*Dendrocalamus strictus*).

The stomata are mostly on the underside, in longitudinal bands over the chlorophyll

parenchyma, which alternate with bands without stomata (Pl. 13. fig. 28, *Melocanna bambusoides*; Pl. 14. fig. 37, *Ochlandra Beddomei*, Gamble). On the upperside the stomata are found sparingly between the longitudinal nerves and the bands of bulliform cells (Pl. 11. fig. 4, *Arundinaria japonica*, and fig. 9, *Bambusa vulgaris*). The stomata of Bamboos are often surrounded by remarkable excrescences, fully described by Wendelbake and shown in figs. 2 & 4. These excrescences are employed by him to distinguish several species of *Arundinaria* and *Phyllostachys*. Into this subject I have been unable to enter.

I have already explained that in Bamboos the bulliform cells are frequently filled with silica. So are, as described in detail by Grob, many of the short cells (Pl. 13. fig. 23, *Dinochloa andamanica*; fig. 21, *Cephalostachyum pallidum*). In addition to these, many of the linear or oblong epidermis-cells of the upper, as well as of the under side are often completely filled with silica (Pl. 11. fig. 11, *Pseudostachyum polymorphum*; Pl. 13. fig. 21, *Cephalostachyum pallidum*; fig. 22, *C. capitatum*; fig. 27, *Melocanna bambusoides*). On the underside they are not rarely found clasping the stomata (fig. 38, *Ochlandra Beddomei*). This, however, is not a character peculiar to Bamboos. Grob figures linear epidermis-cells filled with silica in *Leptaspis conchifera*, t. 4. fig. 1 (a grass belonging to the tribe of Phareæ, Stapf, in 'Flora Capensis,' which, as will be explained further on, in regard to leaf-structure is closely allied to Bamboos), as well as in two species of the tribe Andropogoneæ, *Andropogon Ischæmum*, t. 3. fig. 19, and *Ischæmum petiolare*, t. 3. fig. 16. They will doubtless be found in many other species.

It may here be mentioned that the tendency to deposit silica in the cells of Bamboo leaves is not limited to the cells of the epidermis, but that cells of the chlorophyll parenchyma and even the apparent cavities are often filled with solid bodies of silica. Instances are shown in Pl. 12. fig. 15, *Dendrocalamus Hamiltonii*, where the apparent cavities and the chlorophyll-cells with folded walls are filled, and in Pl. 11. fig. 11, *Pseudostachyum polymorphum*, where some of the silica-filled chlorophyll-cells shine through the epidermis.

I have already stated that leaves, while rolled up in bud, contain no silica in the bulliform cells. Nor have I found any of the other epidermis-cells filled with silica. So far as I have been able to ascertain, the deposit of silica does not take place until the leaves have attained their full size and are spread out flat. But, apart from this, the amount of solid silica deposited in the cells of the epidermis varies within wide limits in leaves of the same species. It must be distinctly understood that the deposits of silica in the bulliform or other epidermis cells of Bamboos cannot be used as a character to distinguish species, although, as will presently be shown, certain species seem to have a stronger tendency than others to accumulate silica in these cells. The following is a list of the Indian species of *Arundinaria* of which I have been able to examine specimens. The procedure, as stated above, is exceedingly simple. Pieces of the leaves are boiled in water for some time and then placed in a concentrated solution of phenol (100 parts crystallized phenol and 10 parts water) for two or three days. The solid contents of the cells then appear with great precision. It will be seen that of the 24 species enumerated, 4 have a strong tendency in the direction here indicated

(*Arundinaria Wightiana, A. falcata, A. khasiana*, and *A. callosa*), but that in these and other species there is great difference in this respect in specimens grown in different localities.

1. *Arundinaria Wightiana*, Nees. Half the bulliform cells filled with silica.
2. *A. Walkeriana*, Munro. Bulliform cells filled with silica few, in interrupted lines.
3. *A. densifolia*, Munro. Bulliform cells filled with silica scattered, or in single, sometimes double, lines; short silica-cells over longitudinal nerves larger and prominent.
4. *A. racemosa*, Munro (6000–9000 feet). Bulliform cells filled with silica few; linear epidermis-cells filled with silica numerous.
5. *A. elegans*, Kurz. Bulliform cells filled with silica few.
6. *A. falcata*, Nees. (1) Mussoorie: Half the bulliform cells filled with silica. (2) Seoraj: One-fourth of the bulliform cells filled with silica. (3) Chakrata, (4) Dehra Dun: Bulliform cells filled with silica scattered; many linear epidermis-cells filled with silica. (5) Cult. Kew: Bulliform cells filled with silica very few; solid silica in the apparent cavities.—All specimens of this species have conspicuous short cells over longitudinal nerves filled with silica.
7. *A. khasiana*, Munro. (1) Sikkim: Half the bulliform cells filled with silica; linear epidermis-cells filled with silica very numerous. (2) Khasi Hills: Bulliform cells filled with silica very few.
8. *A. intermedia*, Munro. (1) Sikkim: One-fourth of the bulliform cells filled with silica. (2) Cult. Hort. Kew: Very few bulliform cells filled with silica.
9. *A. Hookeriana*, Munro. (1) Sikkim: One-sixth of the bulliform cells filled with silica. (2) Cult. Ireland: Very few bulliform cells filled with silica.
10. *A. Griffithiana*, Munro. Khasi Hills. Bulliform cells with silica very few.
11. *A. callosa*, Munro. (1) Khasi Hills, C. B. Clarke leg.: Nearly all bulliform cells filled with silica; linear epidermis-cells filled with silica very numerous. (2) Shillong: Bulliform cells filled with silica few. (3) Kala Naga Hills, Manipur: Bulliform cells filled with silica few; short silica-cells numerous and very conspicuous over nerves and parenchyma.
12. *A. armata*, Gamble. Upper Burma. Few bulliform cells filled with silica; linear epidermis-cells here and there filled with silica.
13. *A. spathiflora*, Trinius. One-third to one-half of the bulliform cells filled with silica.
14. *A. aristata*, Gamble. Few bulliform cells filled with silica.
15. *A. Falconeri*, Benth. & Hook. f. Few bulliform cells filled with silica.
16. *A. Prainii*, Gamble. One-fourth to one-third of the bulliform cells filled with silica.
17. *A. Mannii*, Gamble. Few bulliform cells filled with silica.
18. *A. Clarkei*, Gamble. One-sixth of the bulliform cells filled with silica.
19. *A. jaunsarensis*, Gamble. Few, up to one-sixth, of the bulliform cells filled with silica.
20. *A. Rolloana*, Gamble. Few bulliform cells filled with silica.
21. *A. Ladingiva*. Near the edge half the bulliform cells filled with silica, few in the rest of the leaf.
22. *A. hirsuta*, Munro. Few, up to one-sixth, of the bulliform cells filled with silica.
23. *A. microphylla*, Munro. Few, up to one-sixth, of the bulliform cells filled with silica.
24. *A. suberecta*, Munro. Few, up to one-sixth, of the bulliform cells filled with silica.

Of other genera the following species have a strong tendency to accumulate silica in the cells of their epidermis:—

1. *Phyllostachys bambusoides*, Sieb. et Zucc. (1) Japan: One-half to all bulliform cells filled with silica; short epidermis-cells filled with silica very conspicuous; few linear epidermis-cells with silica. (2) China: One-fourth to one-half of bulliform cells filled with silica; short silica-cells

very conspicuous; linear silica-cells numerous. (3) Cult. Kew: Few bulliform cells with silica.

2. *Bambusa affinis*, Munro. Yunzalia. One-half to all bulliform cells filled with silica; short silica-cells prominent.
3. *B. burmanica*, Gamble. Katha. One-half to all bulliform cells filled with silica; short silica-cells very conspicuous.
4. *B. pallida*, Munro. Silhet. Nearly all bulliform cells filled with silica; short silica-cells very conspicuous.
5. *Oxytenanthera albo-ciliata*, Munro. Burma, from different localities. One-half to all bulliform cells filled with silica.
6. *Dendrocalamus latiflorus*, Munro. Formosa. One-fourth to one-half of bulliform cells filled with silica.
7. *Cephalostachyum capitatum*, Munro. Nearly all bulliform cells filled with silica; linear epidermis silica-cells numerous.
8. *C. pallidum*, Munro. One-half to all bulliform cel's filled with silica.
9. *C. latifolium*, Munro. Nearly all bulliform cells filled with silica.
10. *Melocanna bambusoides*, Trinius. (1) From different localities: One-fourth to one-half of bulliform cells filled with silica; linear silica-cells numerous. (2) Cult. in Kew Palm-house: The same, but without linear silica-cells.
11. *Ochlandra Rheedii*, Benth. One-half to all bulliform cells filled with silica.
12. *O. Beddomei*, Gamble. One-fourth to one-half bulliform cells filled with silica.
13. An undescribed species of *Atractocarpa*, Franchet, from tropical Africa. One-fourth to one-half of the bulliform cells filled with silica.
14. *Chusquea Quila*, Kunth. Chili. One-fourth to one-half of the bulliform cells filled with silica; linear silica-cells numerous.
15. *Nastus borbonicus*, Gmelin. Bourbon. Half the bulliform cells filled with silica.

The data here brought together give no indication regarding the effect of climate and other conditions upon the accumulation of solid silica in the epidermis-cells of mature leaves. The study of one species, however, not included in the above list (*Dendrocalamus strictus*, Nees), has given me some facts which may be found suggestive. This species grows both in the most tropical climate of Burma and the west side of the Peninsula, as well as in the dry region of North-west India, on the Aravalli Hills, the Salt Range, and the Sub-Himalayan tract, nearly to the Indus. Specimens collected in the Punjab, with a rainfall of 30 in., show an abundance of silica-bodies in the bulliform cells as well as in the short epidermis-cells. Specimens collected in Pegu, under a rainfall of 60–80 in., have, in the bulliform cells, few silica-bodies in short lines, while linear epidermis-cells filled with silica are numerous. Leaves grown at Dehra Dun, with an intermediate climate (rainfall about 50 in.), have the silica-bodies of the bulliform cells in interrupted lines, while linear epidermis-cells filled with silica are numerous. At the same time I may mention that on a transverse section the apparent cavities are much longer in the leaves grown in Pegu than in those grown in the Punjab. Apart from the difference in rainfall and atmospheric moisture, there is also a great difference in temperature. December, January, and February are cold months in the Punjab, not uncommomly with severe frost, while Pegu has no winter.

Besides *Dendrocalamus strictus*, there are very few Indian species which grow under climatic conditions so different. *Bambusa nutans*, Wall., grows in Assam, and is cultivated north-west as far as Kangra; *Dendrocalamus Hamiltonii*, Nees et Arnott, is indigenous in both Upper and Lower Burma, and stands the much drier and colder climate of the Kangra Valley. Mr. Gamble, while Director of the Dehra Dun Forest School, introduced many Bamboos from Burma, which are now flourishing in the Forest School Park in a climate quite different from that of their native country. Again, many Indian Bamboos are cultivated in Cairo, and many Bamboos from Japan and the Himalaya are cultivated in different parts of Europe. Abundant material, therefore, can be had in order to investigate the effect of climate upon the formation of silica-bodies in the cells of Bamboo leaves.

In connection herewith I wish to draw attention to the remarkable fact that the leaves of some species cultivated in Great Britain have a much smaller number of silica-bodies in their bulliform cells than specimens collected in their native country. I may quote as instances: *Arundinaria falcata*, *A. intermedia*, *A. Hookeriana*, and *Phyllostachys bambusoides*. Other species I hesitate to quote, as I am not sufficiently certain regarding the identification of the specimens cultivated in Europe. On the other hand, *Melocanna bambusoides*, raised at Kew from seeds (fruit) sent by Mr. A. E. Wild from Bengal, shows the same degree of silification of the epidermis-cells as specimens collected in their native country.

Duval-Jouve, on p. 299 of his 'Histotaxie,' draws attention to the remarkable differences in structure which he had observed in leaves at the base of the culm and higher up at different levels in *Dactylis glomerata* and other Grasses. In the case of Bamboos, it will be interesting to compare the leaves of seedlings, of leaf-bearing culms, and of the few leaves which remain on a flowering culm, as well as the leaves of an annually flowering species from a culm terminated by a flower-panicle and from a leaf-bearing shoot. He further justly lays stress, in comparative researches of this kind, upon the necessity of always examining full-grown leaves and of making the sections in the same place. He selected the lower third of the blade, while the sections examined by me were taken in the middle of the leaf, halfway between base and apex.

Structure of Leaf-sheaths.

The leaf-sheaths of Bamboos are green, they have stomata on their outer epidermis and chlorophyll in their tissue. It is true, the stomata are not numerous and the chlorophyll not abundant, nevertheless they may be supposed to have functions similar to those of leaves and yet their structure is entirely different. Duval-Jouve ('Histotaxie,' t. 16. fig. 14) has figured the structure of the leaf-sheath of *Gynerium argenteum*, Linn., and my Pl. 11. fig. 6 and Pl. 14. fig. 36 exhibit that of *Arundinaria japonica*, Sieb. et Zucc., and of *Melocanna bambusoides*, Trinius. Under the outer epidermis we find a large number of vascular bundles, connected, as in the leaves, by transverse veins and supported under the epidermis on the outside by girders of sclerenchymatous fibres. No

bulliform cells in the epidermis, no apparent cavities in the mesophyll, and no folds in the walls of the parenchyma-cells.

Distinguishing Characters of Bamboo Leaves.

Güntz (p. 64) justly places Bamboos in a separate class with regard to their leaf-structure. The points he chiefly lays stress upon are the thick-walled epidermis with numerous protuberances, the large cavities in the mesophyll, and the scarcity of water-tissue. But there are many more points in regard to which the structure of Bamboo leaves differs from that of the leaves of other Grasses, and they may be stated as follows:—

The vernation is always convolute and the full-grown leaves are flat with a prominent midrib, which consists of two girders of sclerenchymatous fibres, one under the upper, the other under the lower epidermis, and a number of vascular bundles in two lines.

The walls of the linear epidermis-cells are always wavy, the short cells alternating with them being rectangular elliptic or saddle-shaped. Stomata abundant on the lower epidermis over the chlorophyll parenchyma, in belts alternating with belts without stomata. Long hairs and short ones of different shapes and protuberances, blunt and pointed, on the lower epidermis. Upper epidermis generally smooth with few scattered stomata; hairs and protuberances in a few species only (*Melocanna bambusoides*).

Bands of bulliform cells only in the upper epidermis, alternating with longitudinal nerves. In full-grown leaves of most species a large portion of the bulliform cells filled with solid silica.

The longitudinal nerves have always two girders of sclerenchymatous fibres, one below the upper, the other below the lower epidermis. The vascular bundles of longitudinal nerves have two sheaths of elongated cells, an outer parenchyma-sheath and an inner of thick-walled elements, the mestome-sheath. No continuous bands of sclerenchymatous fibres under the lower epidermis, nor, as a rule, girders of such fibres on the underside under the band of bulliform cells.

Large apparent cavities in the mesophyll between the longitudinal nerves and the bands of bulliform cells, which are filled by flat thin-walled cells, lying upon each other, like the leaves of a book. While the leaves are rolled up in bud, these flat cells are filled with a watery fluid and are turgid; when full-grown and spread out flat, the walls collapse, leaving large intercellular spaces between the collapsed walls.

The chlorophyll-tissue fills up the entire space between the longitudinal nerves, epidermis, and apparent cavities; it is never limited to cylinders around the vascular bundles. All chlorophyll-cells have peculiar folds in the membrane, dividing each cell into a number of usually incomplete cylindrical tubes.

Leaf-structure: Biological and other Peculiarities of Bamboos.

In Bamboos most of the principal features of their life-history are the same as in other Grasses, but they have certain important peculiarities, and a Bamboo forest is something

sui generis. We will begin with those species which flower periodically after long intervals at the same time in one district. Instances are *Bambusa arundinacea*, Willd., *B. polymorpha*, Munro, and *Melocanna bambusoides*, Trinius. The culms, which at that time are about thirty years old, die after ripening their seed. After the fires of the next hot season have swept away the tangled mass of dry stems, the rainy season produces millions of seedling Bamboos, which soon grow up into slender plants, 2–3 feet high, forming dense waving green thickets. Among these millions of plants, the stronger gradually get the upper hand, and these in the course of time develop those remarkable rhizomes which in tufted species (*Bambusa arundinacea*, *B. polymorpha*) consist of innumerable stout, twisted, and interlacing branches, but in single-stemmed species (*Melocanna bambusoides*) have long underground creeping stems.

These rhizomes produce culms, which at first are slender, but as the rhizome matures year after year get stouter and taller, until (in the species named) at the end of from eight to twelve years they attain full size. During this period the action of the leaves and roots is mainly directed to form and strengthen the rhizome and to accumulate in its branches starch and other reserve substances. As is well known, the full-sized culm attains its full height, which in some species reaches 120 feet, within about 30 days, a mean increase in height of 4 feet in 24 hours. The first leaves on the young culm do not develop until it has nearly attained its full height. A large portion of the culm is enclosed in the hard leathery culm-sheaths, which serve as a support to the soft tissue of the growing culm, but which are not green and have no stomata. The extremely rapid growth of the young culm is maintained by the action of the leaves of the older culms and by the accumulated reserve substances of the rhizome. During the long period which intervenes between the appearance of the first full-sized culm and the flowering of the species, the action of the leaves to a great extent is directed towards gradually forming and accumulating these reserve substances, which are required for the formation of flowers and seed.

Matters are similar in the case of those species which flower in a more irregular fashion; of these species *Dendrocalamus strictus* is the best-known example. One or a few culms in one clump, or a few clumps in one locality, are in flower at any time, while at other times all culms of one clump and all clumps in one district are simultaneously covered with flowers.

There is a third class: those species which flower annually or nearly so, the flower-panicle terminating the leaf-bearing culms (*Arundinaria Wightiana*, Nees, *Ochlandra Rheedii*, Benth., *O. stridula*, Thwaites).

The duty of the leaves is the same in the case of all three classes; in conjunction with the action of the roots the leaves accomplish two results, the formation and increase of the rhizome and fresh culms, and the accumulation of reserve substances which enable the species to produce flowers and seed. The leaves, not of Grasses only but of all other perennial and woody plants, have to perform similar duties, and the examination of the life-history of Bamboos does not enable us to suggest a physiological significance of the peculiar structure of Bamboo leaves.

Bamboos differ from most other Grasses in this, that in most species the culms are

perennial, but, as a rule, with a different duration of life. In *Bambusa arundinacea*, for instance, the first culms which attain full size are, say, 20 years old when they flower and die, whereas the culms subsequently produced year after year are younger.

In common with many other Grasses, Bamboos are eminently gregarious, they readily get the upper hand in a forest and make it very difficult for other trees to come up. But there are many other gregarious trees and shrubs, Beech and Spruce in Europe, and *Dipterocarpus tuberculatus*, Roxb., *Shorea robusta*, Gaertn. f., several Oaks, Pines, and many species of *Strobilanthes* in India, which are eminently gregarious plants, which, so far as known, have no peculiarities in the structure of their leaves analogous to those which give to Bamboo leaves their peculiar character.

The uniformity of the structure of Bamboo leaves is very remarkable, considering the great morphological differences in that order. Of Indian Bamboos four genera, *Dinochloa*, *Melocalamus*, *Melocanna*, *Ochlandra*, have no endosperm in the ripe seed, a discovery which will, I hope, soon be published by Dr. Otto Stapf, as the result of his researches, in continuation of his paper on *Melocanna bambusoides*. Two genera, *Gigantochloa* and *Oxytenanthera*, together with *Ochlandra travancorica*, Benth., have monadelphous stamens. *Arundinaria* and *Phyllostachys* have 3 and *Ochlandra* 6–120 stamens. In spite of this great variety in regard to important morphological characters, the structure of the leaves is the same in all genera and species, so far as they have been examined.

I believe I am justified in recommending the thorough study of Bamboos to younger botanists. The main part of the work, however, must be done in countries where Bamboos are indigenous, and the first operation must be to establish facts.

The Tribe PHAREÆ.

Somewhere (I cannot now trace the paper) it has been stated that the leaves of *Olyra* have a structure similar to those of Bamboos. This genus Dr. Stapf, in 'Flora Capensis,' vii. p. 319, has placed under a new tribe *Phareæ*, and he has kindly informed me that three other genera, two of which appear under *Paniceæ* in Bentham and Hooker's 'Genera Plantarum,' in his opinion belong to the same tribe. This has induced me to examine specimens of these four genera. The material at my disposal was scanty, but it may be useful briefly to state the result of my observations.

1. *Olyra latifolia*, Linn. A perennial grass 3–8 feet high, of tropical and subtropical America and Africa. Bulliform cells and apparent cavities as in Bamboos, most of the former as well as a large proportion of the linear epidermis-cells filled with silica. Short epidermis-cells filled with silica numerous and conspicuous. Upper epidermis smooth, lower uneven. Parenchyma-sheath and mestome-sheath of vascular bundles as in Bamboos.

2. *Olyra floribunda*, Raddi. Brazil. Bulliform cells, parenchyma-sheath, and mestome-sheath of vascular bundles as in Bamboos. Apparent cavities narrow, the thin-walled cells in them containing chlorophyll. Chlorophyll-cells with distinct folds. Upper epidermis uneven. Midrib: three vascular bundles on the underside.

3. *Diandrolyra bicolor*, Stapf, in Kew Bulletin, 1906, p. 204. (Pl. 14. figs. 44, 45.) Bulliform cells numerous, often occupying the entire interval between two longitudinal nerves, gradually decreasing to the size of epidermis-cells. Apparent cavities very narrow, the thin-walled cells in them before collapsing containing chlorophyll (fig. 45). Midrib: one vascular bundle only on the underside. Parenchyma and mestome-sheath of vascular bundles in longitudinal nerves as in Bamboos. Chlorophyll-cells with distinct folds.
4. *Pharus latifolius*, Linn. (*P. scaber*, Humb. Bonpl. et Kunth in Martius's Fl. Brasil. ii. 2, p. 20). Tropical America. Bulliform cells continuous between longitudinal nerves, all of nearly equal size, not filled with silica. Apparent cavities large, chlorophyll parenchyma scanty. Midrib with two belts of vascular bundles under the girders of sclerenchymatous fibres. Linear and short epidermis-cells filled with silica, conspicuous; numerous long slender hairs appressed to epidermis. Transverse veins unusually stout.
5. *Leptaspis urceolata*, R. Br. Malaya. 1–2 feet high. Bulliform cells, not filled with silica, scarcely larger than the other cells of the upper epidermis, surface of upper epidermis uneven. Apparent cavities large, chlorophyll parenchyma scanty. Midrib with only one vascular bundle on the underside. Short epidermis-cells filled with silica, numerous and very prominent. Many long slender hairs appressed to epidermis. Transverse veins unusually stout.

These remarks will make it clear that in some but not in all respects the leaves of these genera have the structure of Bamboos. It will be a matter of considerable interest to ascertain whether any other genera of Grasses are in a similar position. With reference to the cells in the apparent cavities of *Diandrolyra* containing chlorophyll, it may be noted that the analogous cells of *Dinochloa Macclellandii* may also possibly contain chlorophyll when young.

Bibliography.

1. Ettingshausen, C. von.—Beitrag zur Kenntniss der Nervation der Gramineen. Sitzungsberichte der kaiserl. Akad. der Wissenschaften Wien, vol. lii. (1865), pp. 405–432.
2. Munro, W.—A Monograph of the Bambusaceæ. Trans. Linn. Soc. xxvi. (1868), pp. 1–157, tt. 1–6.
3. Karelstschicoff, S.—Die faltenförmigen Verdickungen in den Zellen einiger Gramineen. Bulletin de la Société Impériale des Naturalistes de Moscou, xli. i. (1868), pp. 180–190.
4. Duval-Jouve, J.—Étude anatomique de quelques Graminées, et en particulier des *Agropyrum* de l'Hérault. Mémoires de l'Académie des Sciences et Lettres de Montpellier (1870), pp. 309–406, tt. 16–20.
5. —— Histotaxie des feuilles de Graminées. Annales des Sciences Naturelles, Botanique, 6e série, tome i. (1875), pp. 294–371, tt. 16–19.
6. Haberlandt, G.—Vergleichende Anatomie des assimilatorischen Gewebesystems der Pflanzen. Pringsheim, Jahrbücher, xiii. (1882), pp. 74–188, tt. 3–8.
7. Tschirch, A.—Beiträge zu der Anatomie und dem Einrollungsmechanismus einiger Grasblätter. Pringsheim, Jahrbücher, xiii. (1882), pp. 544–568, tt. 16–18.
8. Hackel, E.—Monographia Festucarum europæarum. Kassel und Berlin (1882), pp. xi, 216, t. 4.
9. Güntz, H. E. M.—Untersuchungen über die anatomische Structur der Gramineen Blätter, u. s. w. Diss. Leipzig (1886), pp. 72.

10. Volkens, G.—Die Flora der Aegyptisch-Arabischen Wüste auf Grundlage anatomisch-physiologischer Forschungen dargestellt. Berlin (1887), pp. viii, 156, tt. 1–18.

11. Kohl, F. G.—Anatomisch-physiologische Untersuchung der Kalksalze und Kieselsäure in der Pflanze, u. s. w. Marburg (1889), pp. xii, 314, tt. 1–8.

12. Hackel, E.—"Andropogoneæ" in Monographiæ Phanerogamarum, vi. Paris (1889), pp. 1–716, tt. 1, 2.

13. Schwendener, L.—Mestomscheiden der Gramineenblätter. Sitzungsb. der kg. preuss. Akad. d. Wiss. in Berlin, xxii. (1890), pp. 405–426, t. 4.

14. Holm, T.—Anatomical Characters of North-American Gramineæ.—I., II. *Uniola*. Botanical Gazette, xvi. (1891), pp. 166–171, t. 15, pp. 219–225, tt. 21, 22; III. *Distichlis* and *Pleuropogon*. Ib. pp. 275–281, tt. 23, 24; IV. & V. *Leersia*. Ib. xvii. (1892), pp. 358–362, t. 21; xx. (1895), pp. 362–365, t. 26; VI. *Oryza sativa*. Ib. xxi. (1896), pp. 357–360, tt. 27, 28.

15. Gamble, J. S.—The Bambuseæ of British India. Annals of the Royal Botanic Garden, Calcutta, vii. (1896), pp. xix, 133, 3, 4, tt. 1–119.

16. Raunkiær, C.—De Danske Blomsterplanters Naturhistorie, i. Kjöbenhavn (1895–1899), pp. lxix, 724, fig. 1089.

17. Grob, A.—Beiträge zur Anatomie der Epidermis der Gramineenblätter. Bibliotheca Botanica, vii. (1896), pp. 1–123, tt. 1–10.

18. Pée-Laby, E.—Étude anatomique de la feuille des Graminées de la France. Annales des Sciences Naturelles, Botanique, 8me série, viii. (1898), pp. 227–346, tt. 11–13.

19. Makino, T., and Shibata, K.—On *Sasa*, a new Genus of Bambuseæ. The Botanical Magazine, Tokyo, xv. (1901), p. 18.

20. Marshall Ward, H.—Grasses. Cambridge (1901), pp. viii, 190.

21. Wendehake, B.—Anatomische Untersuchungen einiger Bambuseen. Heidelberg (1901), pp. 57, II. 2.

22. Lewton-Brain, L.—On the Anatomy of the Leaves of British Grasses. Trans. Linn. Soc. ser. 2. Bot. vi. (1903), pp. 315–359, tt. 36–40.

23. Matsumura, K.—Index plantarum Japonicarum, ii. 1 (1905), p. 88.

EXPLANATION OF THE PLATES.

Abbreviations used.

a.c. = apparent cavity.
b.c. = bulliform cells.
chl.par. = chlorophyll parenchyma.
e.s. = epidermis-cells filled with silica.
f.c. = flat thin-walled cells.
i. = intermediate band without stomata.
i.e. = inner epidermis.
l.e. = lower epidermis.
l.thin. = large thin-walled cells.
n. = longitudinal nerves.
o.e. = outer epidermis.
p.s. = parenchyma-sheath.
s. = band with stomata.
s.n. = stout nerves.
s.s. = short epidermis-cells filled with silica.
tr.v. = transverse veins.
u.e. = upper epidermis.
v.b. = vascular bundle.

(All figures have been drawn with the camera lucida.)

Plate 11.

Fig. 1. *Arundinaria falcata*, Nees. Mussoorie. × 110. Surface view of the leaf mounted in phenol, with one stout and five slender nerves. The short cells over nerves and the bulliform cells, both filled with silica, conspicuous.

2. *A. japonica*, Sieb. et Zucc. Hort. Kew. × 325. Transverse section of part of a very young leaf, rolled up in bud. Epidermis and vascular bundles formed, the bulliform cells not yet developed, apparent cavities beginning to be developed.

3. *A. japonica*, Sieb. et Zucc. Hort. Kew. × 320. Longitudinal section of a full-grown leaf showing the collapsed walls of the flat thin-walled cells which fill up the apparent cavities between the longitudinal nerves. Transverse veins seen in transverse section.

4. *A. japonica*, Sieb. et Zucc. Hort. Kew. × 325. Upper epidermis with band of bulliform cells and a few scattered stomata.

5. *A. Hookeriana*, Munro. Hort. Kew. × 325. Flat section, parallel with surface of leaf below the upper epidermis, the oblong cells of the chlorophyll parenchyma showing circular folds, arranged in horizontal lines from the parenchyma-sheath of the longitudinal nerve to the band of bulliform cells.

6. *A. japonica*, Sieb. et Zucc. Hort. Kew. × 75. Transverse section of leaf-sheath.

7. *Phyllostachys bambusoides*, Sieb. et Zucc. Hort. Kew. × 320. Transverse section of full-grown leaf, showing bulliform cells, apparent cavities, and folds in the walls of the chlorophyll parenchyma.

8. *P. bambusoides*, Sieb. et Zucc. Hort. Kew. × 320. Longitudinal section of a full-grown leaf, passing through the flat thin-walled cells, which fill up the apparent cavities between longitudinal nerves, walls collapsed.

9. *Bambusa vulgaris*, Schrader. Hort. Kew. × 325. Upper epidermis showing two bands of bulliform cells and one line of stomata.

10. *B. vulgaris*, Schrader. Hort. Kew. × 320. Longitudinal section of a full-grown leaf, passing through the bulliform cells, some of which are filled with silica.

11. *Pseudostachyum polymorphum*, Munro. Sikkim. Upper epidermis, one cell of which is filled with silica; cells of the chlorophyll parenchyma, also filled with silica, shining through.

12. *Dendrocalamus giganteus*, Munro. Hort. Kew. × 75. Transverse section of a full-grown leaf, showing one stout and five slender longitudinal nerves, as well as six bands of bulliform cells.

Plate 12.

Fig. 13. *D. giganteus*, Hort. Kew. × 325. Transverse section of a full-grown leaf, showing bulliform cells fully developed, apparent cavities between longitudinal nerves, folds in the walls of the chlorophyll parenchyma, and, in the lower epidermis, a short cell filled with silica under the vascular bundle.

14. *D. giganteus*, Hort. Kew. × 325. Transverse section of a full-grown leaf at the edge. Outer wall of bulliform cells covered with a thick cuticle. Girder of sclerenchymatous fibres along the edge under the epidermis.

15. *D. Hamiltonii*, Nees et Arn. × 325. Transverse section of a full-grown leaf. Apparent cavities and chlorophyll parenchyma-cells filled with silica.

16. *D. giganteus*, Hort. Kew. × 325. Transverse section of a young leaf not quite flat, the bulliform cells have not yet attained their full size.

Fig. 17. *Dendrocalamus giganteus*, Hort. Kew. × 75. Transverse section of a very young leaf rolled up in bud. Longitudinal furrows, where afterwards the bulliform cells will appear.

18. *D. giganteus*, Hort. Kew. × 325. Longitudinal section through the apparent cavity and transverse vein of a young leaf. The flat thin-walled cells turgescent.

19. *D. strictus*, Nees. × 320. Transverse section through midrib. Groups of large thin-walled cells on both sides of midrib. Hairs on upper and lower epidermis.

20. *D. Hamiltonii*, Nees et Arn. × 75. Transverse section through midrib. Groups of large thin-walled cells. Vascular bundles numerous.

Plate 13.

Fig. 21. *Cephalostachyum pallidum*, Munro. × 75. A surface view of the leaf, mounted in phenol, with three longitudinal nerves and four bands of bulliform cells, all filled with silica. Long and short epidermis-cells filled with silica are conspicuous. Transverse veins faintly visible.

22. *Cephalostachyum capitatum*, Munro. × 325. Upper epidermis with some bulliform and some long epidermis-cells filled with silica.

23. *Dinochloa andamanica*, Kurz. × 320. Transverse section. Vascular bundle with parenchyma and mestome-sheath, bands of bulliform cells in upper epidermis. Short epidermis-cells filled with silica in upper and lower epidermis.

24. *D. andamanica*, Kurz. × 320. Longitudinal section, passing through the flat thin-walled cells which fill up the apparent cavities; walls collapsed.

25. *D. andamanica*, Kurz. × 320. Longitudinal section, passing through the band of bulliform cells.

26. *Melocanna bambusoides*, Trin. × 60. Surface view of leaf near inner edge mounted in glycerine. One stout and four slender nerves. Broad colourless band on the edge, closely set with fine hairs. Transverse veins faintly visible where they cross the band of bulliform cells (pellucid glands, Gamble).

27. *M. bambusoides*, Trin. × 110. Surface view of leaf mounted in phenol. Four nerves joined by distinct transverse veins. Three bands of bulliform cells, half of them filled with silica. A number of linear epidermis-cells filled with silica. The flat thin-walled cells filling cavities visible as transverse lines.

28. *M. bambusoides*, Trin. × 325. Lower epidermis. Over the nerve the short cells large and in pairs, over chlorophyll parenchyma alternating bands with and without stomata. Hairs of two kinds on the band without stomata. The protuberances on the outer wall of the epidermis-cells visible as circles.

29. *M. bambusoides*, Trin. × 110. Transverse section of a mature leaf. One stout and three slender nerves, three bands of bulliform cells alternating with them, girders of sclerenchymatous fibres conspicuous. The intermediate cell, which generally separates the two apparent cavities, is wanting on the left hand of the figure.

30. *M. bambusoides*, Trin. × 325. Transverse section of full-grown leaf. One of the bulliform cells between two vascular bundles filled with silica. Folds in the cells above apparent cavities from the lower edge only.

Plate 14.

Fig. 31. *Melocanna bambusoides*, Trin. × 325. Transverse section of a young leaf, bulliform cells in a longitudinal furrow, not fully developed. Four cells between the apparent cavities.

32. *M. bambusoides*, Trin. × 75. Midrib near base of leaf. The band of tissue above the lower epidermis contains four, that below the upper epidermis also four vascular bundles, most of which are enclosed in the girders of sclerenchymatous fibres. A band of large parenchyma-cells between the two lines of vascular bundles. Groups of large thin-walled cells on both sides of midrib.

33. *M. bambusoides*, Trin. × 325. Midrib in the middle of leaf. The two girders of sclerenchymatous fibres have united, forming a solid mass of stereome between the upper and lower epidermis, beyond the edges of which are a few large parenchyma-cells. The lower part contains three, the upper four vascular bundles, all enclosed in stereome. Two of the vascular bundles in the upper series have an irregular orientation; the leptome of one is lateral, that of another is directed upwards.

34. *M. bambusoides*, Trin. × 325. Midrib below the apex of leaf. The lower line has only one very large vascular bundle, while the upper line consists of three, one of which has an inverted orientation. A band of large parenchyma-cells between the two lines of vascular bundles.

35. *M. bambusoides*, Trin. × 325. Flat section, parallel with surface of leaf above the lower epidermis, showing the flat thin-walled cells (walls collapsed) which fill the apparent cavities, and the chlorophyll parenchyma, which separates the apparent cavities. The oblong cells of the chlorophyll parenchyma show circular folds.

36. *M. bambusoides*, Trin. × 75. Transverse section through leaf-sheath.

37. *Ochlandra Beddomei*, Gamble. Lower epidermis. Over chlorophyll parenchyma alternating bands with and without stomata. The protuberances on the outer wall of epidermis-cells visible as circles.

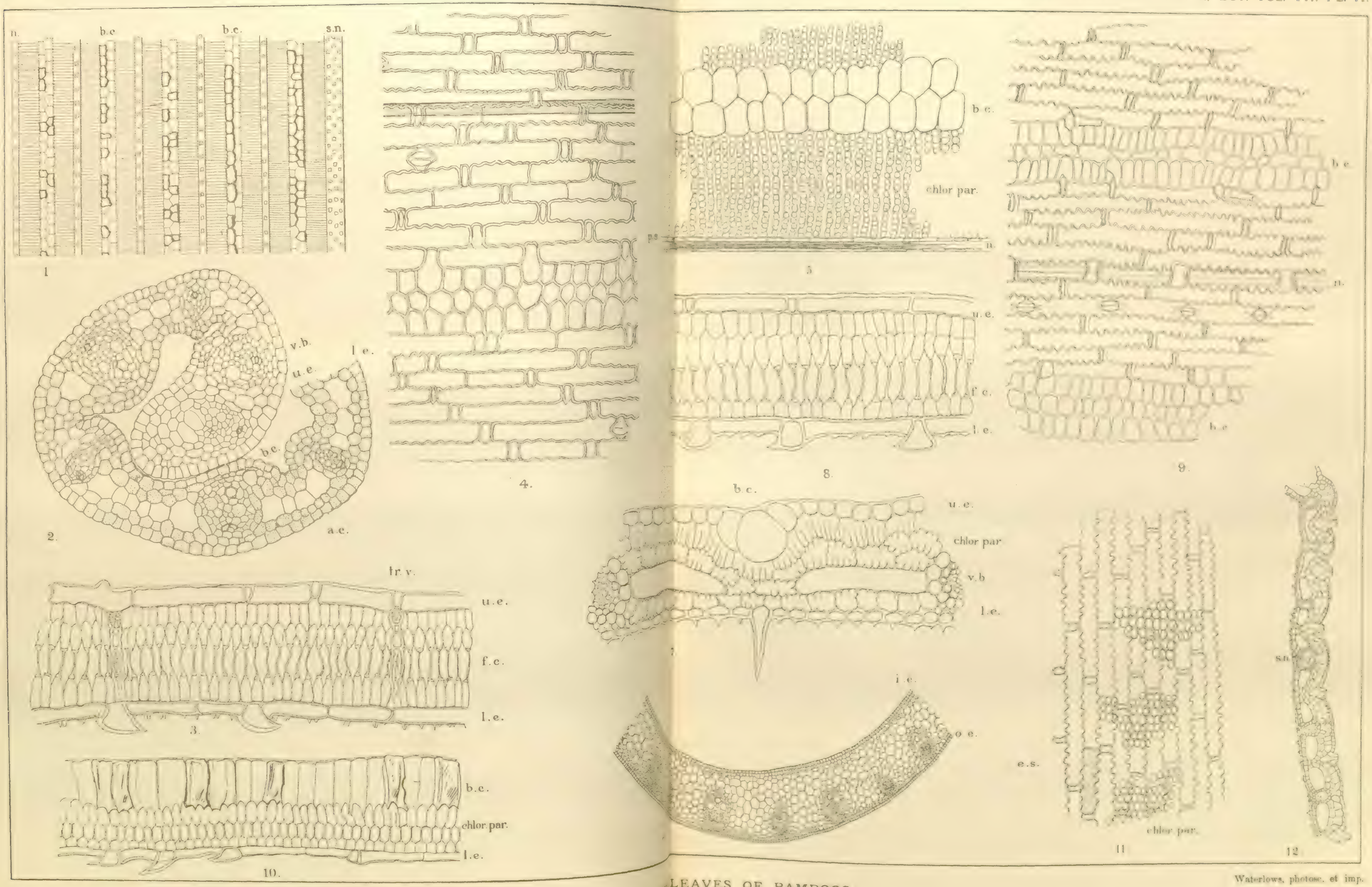
38. *Ochlandra Beddomei*, Gamble. × 325. Lower epidermis. Oblong epidermis-cells, filled with silica and clasping stomata.

39. *Chusquea pinifolia*, Nees. × 75. Transverse section. No midrib, no apparent cavities, but bands of bulliform cells in the upper epidermis between longitudinal nerves.

40–43. Flat thin-walled cells which fill apparent cavities, isolated. × 325. 40. *Sasa paniculata*, Makino and Shibata (*Arundinaria Kumasasa*, Hort. Kew). 41. *Cephalostachyum capitatum*, Munro. 42. *Melocanna bambusoides*, Trin. 43. *Ochlandra Beddomei*, Gamble.

44. *Diandrolyra bicolor*, Stapf. × 325. Transverse section. Between two nerves a band of bulliform cells and two apparent cavities.

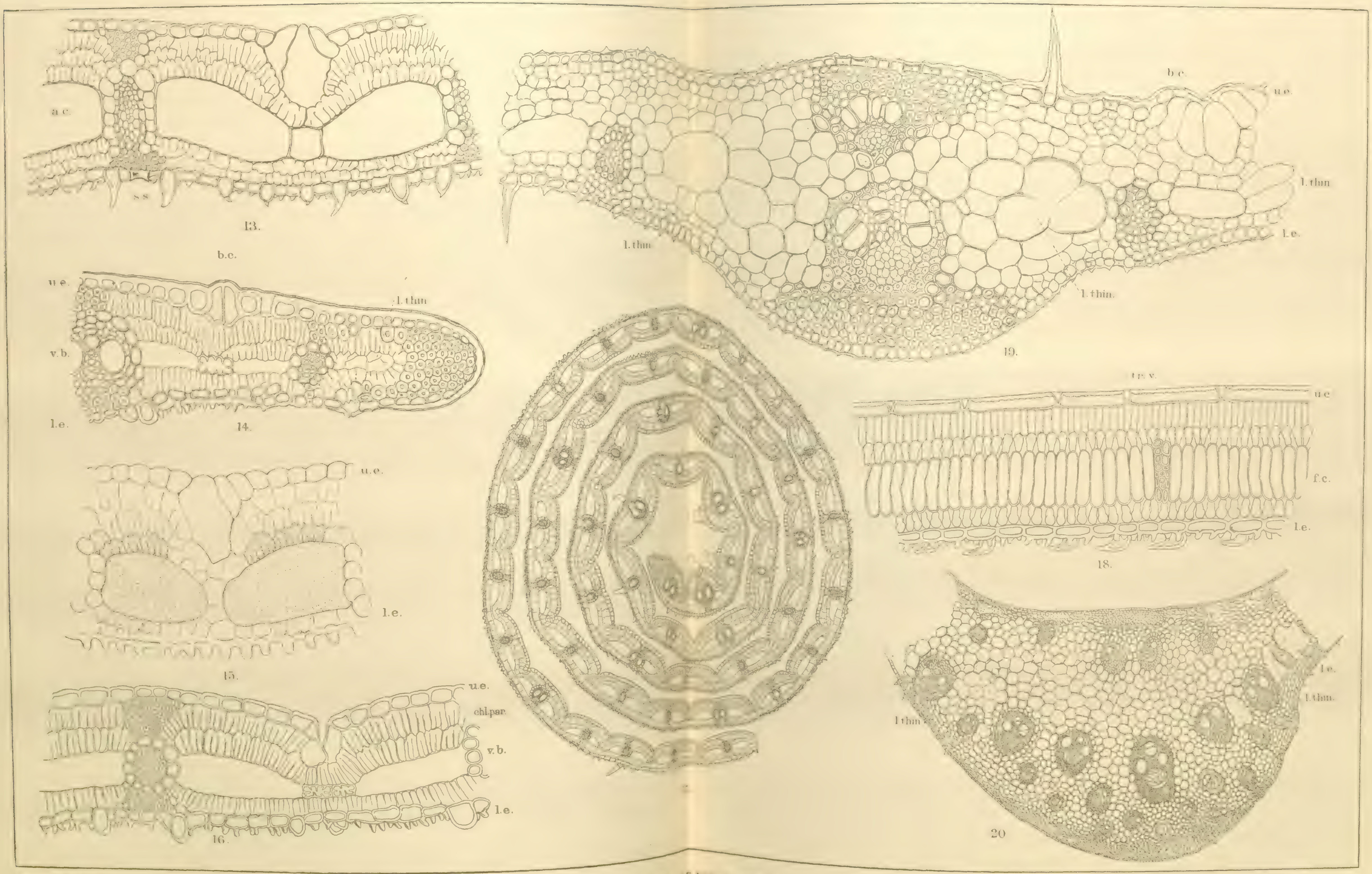
45. *D. bicolor*, Stapf. × 325. Longitudinal section, passing through an apparent cavity. Some of the thin-walled cells have separated, but the walls have not yet collapsed; these contain chlorophyll.



J. N. Fitch, del.

STRUCTURE OF THE LEAVES OF BAMBOOS.

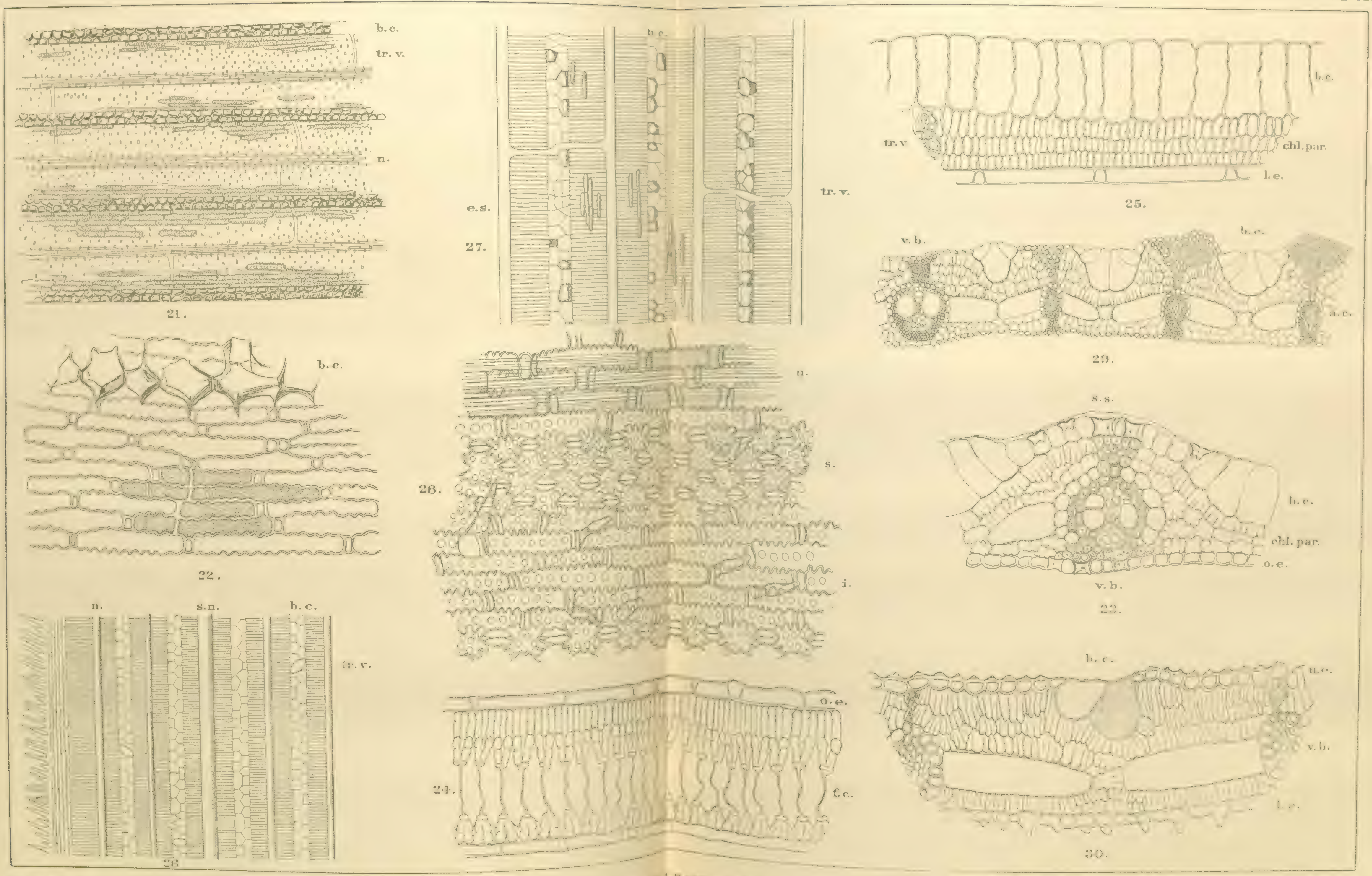
Waterlows, photose. et imp.



J. N. Fitch, del.

STRUCTURE OF THE LEAVES OF BAMBOOS.

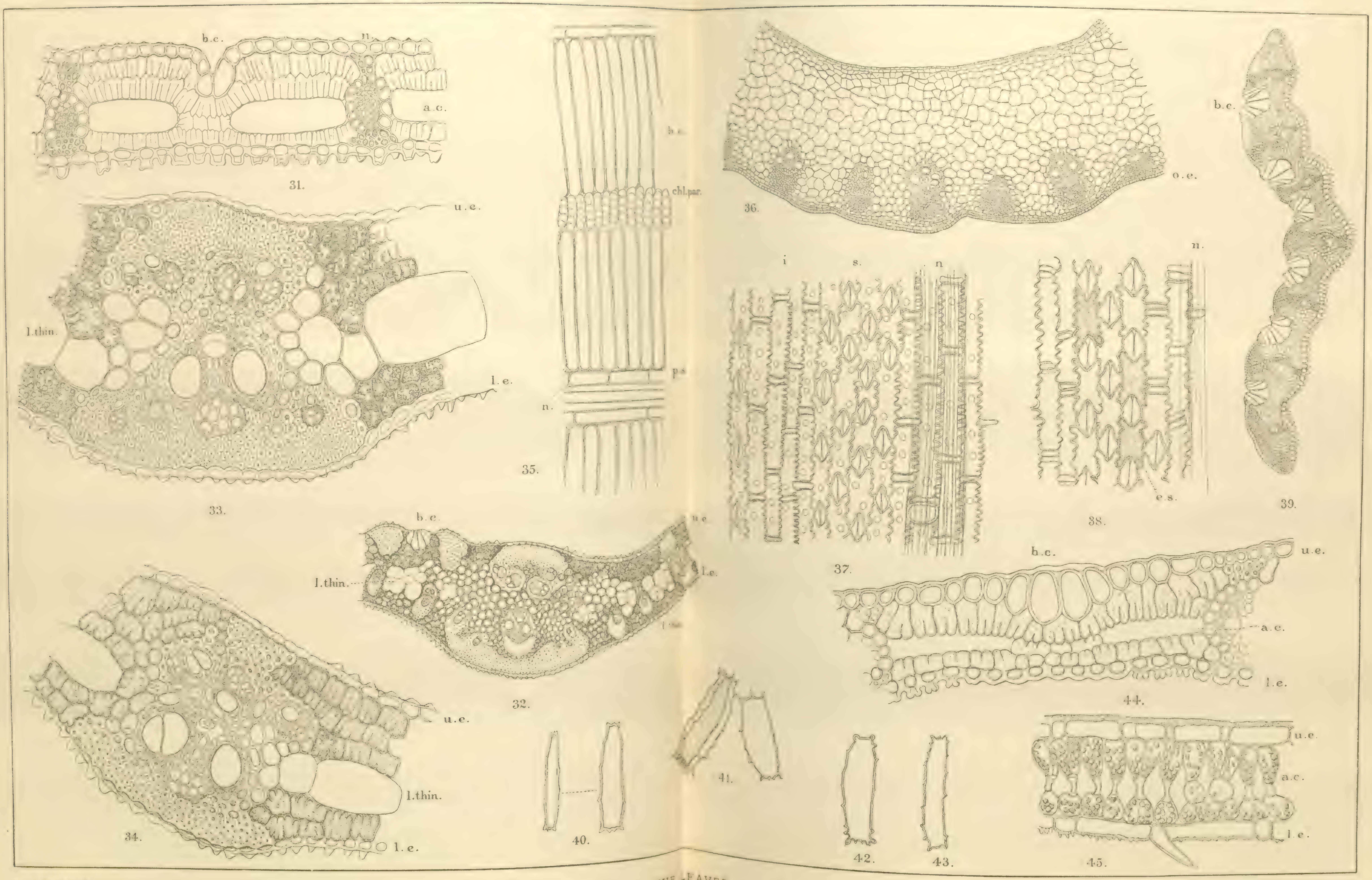
Waterlows, photosc. et imp.



J. N. Fitch, del.

STRUCTURE OF THE LEAVES OF BAMBOOS.

Waterlows, photosc. et imp.



J. N. Fitch, del.

STRUCTURE OF THE LEAVES OF BAMBOOS.

Waterlows, photosc. et imp.

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s.* to the public, and 6*s.* to Fellows; to Vols. 26–30, 4*s.* to the public, and 3*s.* to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

Second Series.—Botany.

Volume.		When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
I.	Part I.	1875.	0	8	0	0	6	0
	Part II.	1875.	0	16	0	0	12	0
	Part III.	1876.	0	12	0	0	9	0
	Part IV.	1876.	0	10	0	0	7	6
	Part V.	1878.	1	4	0	0	18	0
	Part VI.	1879.	1	6	0	0	19	6
	Part VII.	1880.	1	4	0	0	18	0
	Part VIII.	1880.	1	1	0	0	16	0
	Part IX.	1880.	1	0	0	0	15	0
II.	Part I.	1881.	0	12	0	0	9	0
	Part II.	1882.	0	5	0	0	3	9
	Part III.	1883.	0	10	0	0	7	6
	Part IV.	1883.	0	3	0	0	2	3
	Part V.	1883.	0	3	0	0	2	3
	Part VI.	1884.	0	13	6	0	10	0
	Part VII.	1884.	0	9	6	0	7	0
	Part VIII.	1884.	0	10	0	0	7	6
	Part IX.	1886.	0	7	0	0	5	0
	Part X.	1887.	0	3	4	0	2	6
	Part XI.	1886.	0	6	0	0	4	6
	Part XII.	1886.	0	8	0	0	6	0
	Part XIII.	1887.	1	7	0	1	0	0
	Part XIV.	1887.	0	7	0	0	5	0
	Part XV.	1887.	0	10	0	0	7	6
	Part XVI.	1888.	0	2	6	0	2	0
III.	Part I.	1888.	3	12	0	2	14	0
	Part II.	1891.	0	5	0	0	3	9
	Part III.	1891.	0	7	0	0	5	0
	Part IV.	1891.	0	6	0	0	4	6
	Part V.	1891.	0	6	0	0	4	6
	Part VI.	1891.	0	3	6	0	2	8
	Part VII.	1892.	0	6	0	0	4	6
	Part VIII.	1893.	0	6	0	0	4	6
	Part IX.	1893.	1	8	0	1	1	0
	Part X.	1894.	0	10	0	0	7	6
	Part XI.	1894.	0	3	4	0	2	6

Second Series.—Botany (*continued*).

Volume.		When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
IV.	Part I.	1894.	1	0	0	0	15	0
	Part II.	1894.	2	0	0	1	10	0
	Part III.	1895.	2	10	0	1	17	6
	Part IV.	1895.	0	3	4	0	2	6
V.	Part I.	1895.	0	9	0	0	6	9
	Part II.	1895.	0	12	0	0	9	0
	Part III.	1896.	0	6	0	0	4	6
	Part IV.	1896.	1	0	0	0	15	0
	Part V.	1896.	0	14	0	0	10	6
	Part VI.	1896.	0	4	0	0	3	0
	Part VII.	1897.	0	4	0	0	3	0
	Part VIII.	1897.	0	6	0	0	4	6
	Part IX.	1899.	0	12	0	0	9	0
	Part X.	1899.	0	6	0	0	4	6
	Part XI.	1899.	0	7	0	0	5	0
	Part XII.	1899.	0	12	0	0	9	0
	Part XIII.	1900.	0	1	6	0	1	2
	Part XIV.	1900.	0	3	0	0	2	3
	Part XV.	1901.	0	6	0	0	4	6
VI.	Part I.	1901.	1	10	0	1	2	6
	Part II.	1901.	0	6	0	0	4	6
	Part III.	1902.	0	18	0	0	13	6
	Part IV.	1903.	0	8	0	0	6	0
	Part V.	1903.	0	8	0	0	6	0
	Part VI.	1903.	0	12	0	0	9	0
	Part VII.	1904.	0	12	0	0	9	0
	Part VIII.	1904.	0	12	0	0	9	0
	Part IX.	1904.	0	7	0	0	5	3
	Part X.	1904.	0	14	0	0	10	6
	Part XI.	1905.	0	4	0	0	3	0
VII.	Part I.	1904.	0	5	0	0	3	9
	Part II.	1905.	0	6	0	0	4	6
	Part III.	1906.	0	3	0	0	2	3
	Part IV.	1906.	0	7	0	0	5	3
	Part V.	1907.	0	10	0	0	7	6

2nd Ser. BOTANY.] [VOL. VII. PART 6.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

THE LITHOTHAMNIA OF THE PERCY SLADEN TRUST EXPEDITION, IN H.M.S. SEALARK.

BY

M. FOSLIE.

(*Communicated by* Mr. J. STANLEY GARDINER, M.A., F.L.S.)

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

October 1907.

VI. *The* Lithothamnia *of the Percy Sladen Trust Expedition in H.M.S. Sealark.*

By M. Foslie. (*Communicated by* Mr. J. Stanley Gardiner, *M.A., F.L.S.*)

(Plates 15 & 16.)

Read 20th June, 1907.

Great areas of the Indian Ocean, and of other oceans as well, are still unexplored or but little known as regards the occurrence of calcareous algæ of the groups of Lithothamnioneæ and Melobesieæ. These algæ appear everywhere in suitable localities from Spitzbergen and Ellesmere Land in the north to South Victoria Land and Louis Philip Land in the south. They are known to occur in enormous quantities in many places, in the arctic and temperate zones often forming large banks, and in the tropics essentially contributing to the formation of reefs. Their occurrence in masses in fossil and subfossil layers further shows us what important part they have also played in former times. But our knowledge of the different species and of their geographical distribution is as yet rather imperfect, and only the circumstance that during these ten years upwards of 200 new species have been described shows their great abundance of forms.

During the Sealark Expedition Mr. J. Stanley Gardiner collected a rich material of these algæ in an area of the Indian Ocean from which they were hitherto almost unknown. This material he has kindly left me to determine. As to the occurrence of the algæ in the above area, he has given much interesting information *. Below I take permission to quote some of these particulars, with running comments stating the occurrence of different species in various places.

Of the thirteen species collected and mentioned below, two are new to science, viz. *Lithothamnion gibbosum* and *Lithophyllum Gardineri.* They have been provisionally described in 'Algologiske Notiser,' iii.

The Chagos Archipelago.

The parts explored of this Archipelago, from which Lithothamnia have been brought home, are the Salomon and Egmont Atolls. Mr. Stanley Gardiner remarks (*l. c.* p. 2):—"The reefs of the Chagos are in no way peculiar, save in their extraordinary paucity of

* *Investigations in the Indian Ocean.*—First Report of the Committee, consisting of Sir John Murray (Chairman), Mr. J. Stanley Gardiner (Secretary), Captain E. W. Creak, Professors W. A. Herdman, S. J. Hickson, and J. W. Judd, Mr. J. J. Lister, and Dr. H. R. Mill, appointed to carry on an Expedition to investigate the Indian Ocean between India and Africa, in view of a possible land-connection, to examine the deep submerged banks, the Nazareth and Saya de Malha, and also the distribution of Marine Animals.—*British Association Report*, York, 1906.

animal life. Green weed, too, of every sort is practically absent. However, this barrenness is amply compensated for by the enormous quantity of Nullipores (Lithothamnia, &c.), incrusting, massive, mammillated, columnar, and branching. The outgrowing seaward edges of the reefs are practically formed by their growths, and it is not too much to say that, were it not for the abundance and large masses of these organisms, there would be no atolls with surface reefs in the Chagos. The lagoon shoals of Egmont are covered by them, and are the only lagoon reefs in the Chagos that reach the surface; having once done so, they die and become hollowed out, finally resembling miniature atolls." Concerning Salomon, which was carefully surveyed, he remarks that "its face was everywhere singularly barren; *Lithothamnion*, *Polytrema*, and, of course, reef-corals were not obtained below 50 fathoms." Further, he observes in another paper * as to the Chagos:—"Individually the reefs present the same general characters as those of the Maldives. They differ, however, in detail in that their outgrowing edges are, *practically entirely*, formed of Nullipores, though corals are important builders from 5 to 30 fathoms." (*Cp.* the photo *l. c.* p. 331, from Ile de la Passe, Salomon Atoll, showing Nullipore buttress growing out from the seaward edge of the reef.)

The species of calcareous algæ of the group in question occurring so numerously in the Chagos are *Lithophyllum onkodes*, *L. craspedium*, *L. Gardineri*, and *Goniolithon frutescens*. These species thus are important reef-builders, especially the two or three first-mentioned ones, comprising the incrusting, massive, mammillated, and columnar forms, whereas the species last mentioned is a more delicate branching species. It is possible that, besides the species mentioned, other species are also to be found, which the collector may have failed to notice. If so, they are certainly playing no prominent part in the formation of reefs.

At Diego Garcia three species have been collected by the German 'Valdivia' Expedition †, viz.:—small specimens of *Lithoph. onkodes* attached to corals, a specimen of the small crust-like *Lithothamnion simulans* (earlier only known from the Gulf of Siam), and a young specimen of *Lithophyllum Kaiseri* (*pallescens*) mentioned below.

Cargados Carajos.

Near Cargados is, according to the Report (*l. c.* p. 5), "a wonderfully constant depth of 30–35 fathoms over the body of the bank . . . . the bottom was either coral rubble, white sand, shell rubble, or weed. The three latter occurred only in the central parts of the bank . . . . From this rubble, which is of a bright red colour, due to an encrusting nullipore, we obtained a rich variety of animal life, nearly all forms tinted with red."

In this bank, where more than 30 hauls were made, *Lithothamnion indicum* occurred in four localities (No. B 8, B 9, B 13, and B 14), and in two of the same localities (No. B 8 and B 14) also *Lithothamnion australe*, both together with a number of young, stunted or dead and undeterminable specimens not unlikely belonging to the first-named species.

* J. Stanley Gardiner, "The Indian Ocean," The Geographical Journal, October and November, 1906, p. 323.

† The species collected by this expedition at Diego Garcia and Mahé will be mentioned by Mr. Th. Reinbold in 'Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition.'

Besides, in one of the localities (No. B 9), as well as in two others (No. B 28 and B 29), have been collected three larger pieces of calcareous rubble with young crusts of undeterminable Lithothamnia.

Saya de Malha Banks.

From a depth of 55 fathoms (No. C 15) was brought up several specimens of *Lithothamnion australe* growing gregariously with *Lithothamnion gibbosum*. Here also occurred numerous fragmentary or dead and undeterminable specimens, some of which perhaps are stunted forms of *Lithothamnion indicum*. Several of these specimens are in part covered with Squamariaceæ. In a depth of 26 fathoms (No. C 16) was dredged a solitary specimen of *Archæolithothamnion erythræum* and three specimens of *Lithophyllum Okamurai* f. *ptychoides*, together with a calcareous Squamariacea, *Halimeda*, crust-like Foraminifera, &c. In addition, from a depth of 29 fathoms (No. C 19) was picked up one specimen perhaps belonging to *Lithophyllum Okamurai* f. *ptychoides*, in company with a few stunted and undeterminable forms, a calcareous Squamariacea, and some coral-rubble and other rubble with crusts of Lithothamnia, Squamariacea, Foraminifera, &c.

Coetivy.

About this island is remarked in the Report (*l. c.* p. 6):—"Although situated only about 130 miles to the south of the Seychelles Islands, the land fauna and flora are almost the same as on the islands of the Chagos Archipelago, being scarcely richer . . . . On the other hand, the reefs of Coetivy showed in every group of marine animals a more varied fauna than those of the Chagos, while very nearly all the species of the latter seemed to be present. The reef on the eastern or seaward face of the island was of a rather different character from any we had as yet seen, being covered with *Zostera* *. There was also on the same part a considerable variety of algæ, but the edge and outer slope were, as elsewhere, covered by corals and nullipores."

Also with reference to the calcareous algæ in question, Coetivy shows almost the same state of things as the Chagos. The following species have been collected here :—*Lithophyllum onkodes*, particularly occurring on the western reef, *Lithophyllum craspedium*, *L. Gardineri*, and *Goniolithon frutescens*, mainly on the eastern reef, but *Lithophyllum craspedium* apparently less abundant than in the Chagos.

Providence.

A number of small but rather well-developed specimens of *Lithothamnion indicum* have been picked up from a depth of 29–30 fathoms (No. D 3 and D 24), and from a depth of 50–78 fathoms (No. D 4) some stunted specimens of the same species together with some undeterminable ones.

* [This is a mistake for *Cymodocea*.—J. Stanley Gardiner.]

Amirante.

As to the Amirante Bank, Mr. Stanley Gardiner remarks in Ind. Oc. (p. 332): "Its surface is decidedly irregular, as masses of growing corals and nullipores may be found anywhere, but nowhere attains a greater depth than 37 fathoms. On its edges, where nullipores flourish, there is perhaps a greater tendency to growth, but the term 'atoll' cannot as yet be applied to it."

It seems as if well-developed Lithothamnia are not abundant in this place, apart, however, from its surface-reefs, where Lithothamnia probably occur, though they have not been collected. Thus in a depth of 45–60 fathoms (No. E 27) has been dredged a solitary specimen of *Lithothamnion purpurascens* together with a few pieces of small calcareous rubble with young and undeterminable crusts of Lithothamnia and a crust-like Foraminifer in habit reminding of certain forms of Lithothamnia *. From a depth of 30 fathoms (No. E 21) have been brought home small specimens of a calcareous Squamariacea and a Foraminifer of the same kind as mentioned above. Besides, from a depth of 20–25 fathoms (No. E 13) an uncertain stunted specimen of *Lithothamnion indicum*, and from about the same depth (No. E 3) a few pieces forming a conglomerate of stunted, undeterminable Lithothamnia, corals, Bryozoa, as well as the above-mentioned Foraminifer.

The Seychelles Archipelago.

According to Mr. Stanley Gardiner (*l. c.* p. 456), this Archipelago comprises two coral-islands and seventeen granite-islands. "Immediately around the granite-islands are here and there fringing reefs, especially in bays . . . . Nullipores practically do not enter into their composition, and such coral masses as grow are of comparatively small size. Indeed, most owe their origin to the piling up of calcareous and siliceous sand in bays, or to the cutting down and removal of the granite above the sea-level. Yet the absence of nullipores is the important point, nothing else really being wanting for the formation of true coral flats. In no case do these calcareous plants grow well in lagoons or enclosed waters, and their absence from the centre of the Seychelles bank—they grow well on the edges—is presumably due to the churning up of the water and to the removal from it of all carbonic acid gas by seaweeds, etc., before it reaches the islands."

In a depth of 31 fathoms (No. F 2) have been taken three well-developed specimens of *Archæolithothamnion timorense* and two rather stunted specimens of *Lithothamnion indicum*, in company with a few pieces of calcareous rubble partly covered with Squamariacea, partly with the Foraminifera mentioned above. Some specimens of *Lithophyllum Kaiseri* and a couple of specimens of *Lithophyllum moluccense* have been brought home from the reef of Praslin Island. In addition, the German 'Valdivia' Expedition † collected on the coast, or in the neighbourhood, of Mahé Island a

* A similar Foraminifer seems to be abundant at several places in the West Indies, particularly St. Jan and St. Croix, also here growing gregariously with Lithothamnia. It is presumed to represent a species of the genus *Gypsina*.

† *Cf.* the footnote, p. 94.

small specimen of *Goniolithon Fosliei* attached to a piece of coral, together with *Lithothamnion simulans*, small and not well-developed (partly uncertain) crusts of *Goniolithon myriocarpon*, *Lithophyllum Yendoi* f. *mahëica*, and a very young specimen of *Lithophyllum affine* (i. e. *L. Kaiseri* (*pallescens*), cf. below).

On comparing the area in question with other parts of the Indian Ocean we find a close correspondence particularly with the Maldives, the only area in this ocean which was formerly comparatively well known, owing to the collections made by Mr. Stanley Gardiner in the years 1899–1900. This correspondence chiefly concerns the three reef-building species mentioned above, viz., *Lithophyllum onkodes*, *L. craspedium*, and *Goniolithon frutescens*—the fourth species, *Lithophyllum Gardineri*, having hitherto only been found in the Chagos and at Coetivy.

As is observed below, the forms of *Goniolithon frutescens* occurring in the area in question are more consistent with forms of the same species from the Maldives than the forms of the species occurring at the Ellice Islands (Funafuti) in the Pacific Ocean. The same is the case with *Lithophyllum onkodes* and *L. craspedium*, which are also in structure fully consistent with specimens of the same species from the Maldives, whereas, in this respect particularly, the specimens from the area in question and some of those collected at the Maldives are in part a little diverging from the specimens picked up at the Ellice Islands (*cf.* Lithoph. Mald. & Laccad. p. 468).

Thus in rather great areas of the Indian Ocean these three or four species are shown to be important reef-builders in the littoral region and in the uppermost part of the sublittoral region. Besides, also *Lithophyllum Kaiseri* (*pallescens*) and other species here and there contribute to the formation of reefs, but apparently in far less degree than the species mentioned. Farther down in depths of up to about 60 fathoms, *Lithothamnion indicum* as well as *L. australe* seem to be rather essential builders of new strata in places suitable for them, partly alone, partly gregariously, and here and there associated with other species in smaller number.

To judge from our present knowledge of the Lithothamnia within the tropics, it seems that in places where these algæ occur in such abundance and so large masses that atolls with surface-reefs are practically entirely formed by them, as, *e. g.*, in the Chagos, or in places where they are of essential importance for the consolidation of corals into true reefs the number of species is frequently small, but each of them appearing in an enormous number of individuals. Besides in the Chagos, this is the case at Coetivy, at certain places in the Maldives, and at the Ellice Islands (Funafuti), as well as the Gilbert Islands in the Pacific Ocean. In banks which are formed of freely-developed branching specimens in the lowermost part of the littoral region, as, *e. g.*, at Haingsisi in the Malay Archipelago *, or, more frequently, at different depths in the sublittoral region, one species will predominate †. On the other hand, in places where the Lithothamnia do not appear in such quantities, on exposed as well as on protected and suitable localities, a larger variety of species is often found.

* *Cf.* A. Weber van Bosse in 'Siboga' Exp. n. lxi. livr. 18. p. 4.

† In boreal or arctic areas such banks are often formed of only one species.

There seems to be a considerable correspondence as to the Lithothamnia in the Indian Ocean and large areas of the Pacific Ocean within the tropics. This concerns several of the species themselves as well as their mode of occurrence, peculiarly such as determine the general aspect of the vegetation. Thus the three reef-building species mentioned above occur at the Ellice Islands, one of them also at the Gilbert Islands, nearly under the same conditions as at the localities mentioned in the Indian Ocean. At the former islands *Lithophyllum onkodes* is known from, *e. g.*, "reef-platform," "ocean-platform," "thick growth of nullipore from the shoals in the lagoon," and "consolidated rock, forming platform, Hurricane Beach" at Funafuti, from Fualopa and from Pava Islet. *Lithophyllum craspedium* partly grows gregariously with the former species or with *Goniolithon frutescens*, partly alone, *e. g.*, "ocean-platform" Funafuti, and at Fualopa. Besides, at Onoatoa, Gilbert Island, it is "a very abundant type and the most important reef-former," no living coral having been seen there, but "everywhere on the lagoon and ocean-face immense masses" of this calcareous alga. *Goniolithon frutescens* occurs, *e. g.*, on the ocean-platform of Funafuti, at Fualopa, and "is very abundant on the leeward (W.) islets of Funafuti Atoll." It appears on the beach S. of the village, Funafuti lagoon, and on the lagoon-platform at Funafala. Here it is "an important rock-former" and it is "also an important reef-former." Some species, however, which are common to both oceans seem to be more largely distributed in one than in the other, and as a matter of course there are several species which are as yet known only from one of these oceans, and which are rather local and seem to appear in no large numbers anywhere.

Our knowledge of the occurrence of these calcareous algæ in both oceans is, however, as yet so inconsiderable that at present no thorough comparison can be made which can lay claim to any particular interest.

CORALLINACEÆ, (Gray) Harv.

Tribe LITHOTHAMNIONEÆ, Fosl.

Genus Lithothamnion, Phil. (emend.).

Subgenus Eulithothamnion, Fosl.

1. Lithothamnion purpurascens, Fosl.

'Siboga' Exp. n. lxi. livr. 18 (1904), p. 18, in obs.

Lithothamnion funafutiense f. *purpurascens*, Fosl. Corall. in Fl. Koh Chang, in Bot. Tidsskr. xxiv. (1901) p. 18.

With some reservation, I refer a solitary specimen to the above species. It is 3–4 cm. in diameter, and surrounds irregularly crust-like calcareous masses of some kind or other, with rather numerous excrescences mostly small and irregularly wart-like, some of which at least have risen owing to the unevenness of the substratum. It is rather richly furnished with conceptacles of sporangia, which are 400–700 μ in diameter, and essentially agree with those of the species in question, intersected with about 100 muciferous canals.

Conceptacles of cystocarps do not occur. The specimen in structure also mainly resembles *Lithothamnion purpurascens*, forming feebly-marked layers of tissue. It has been dredged at a depth of 45–60 fathoms together with a couple of stunted pieces of another calcareous alga and a crust-like Foraminifer.

Locality. Indian Ocean: the Amirante Bank, No. E 27 (*Stanley Gardiner*).

Area. The Gulf of Siam.

2. LITHOTHAMNION INDICUM, Fosl.

Kgl. Norske Vidensk. Selsk. Skrift. 1906, n. 8 (1907), p. 7 (in Norwegian).

Resembles *Lithoth. fruticulosum* f. *crassiuscula*, but the bottom of the conceptacles of sporangia almost plane or feebly convex according to the shape of the layers of tissue, and particularly the lower corners in a median-vertical section often not or but feebly rounded; conceptacles of cystocarps almost superficial, conical.

f. TYPICA.

Syn. *Lithothamnion fruticulosum* f. *crassiuscula*, Fosl. Lithoth. Mald. & Laccad. in Gardiner, Fauna and Geogr. of the Mald. & Laccad. Archip. i. p. 464, pl. 24. figs. 2, 3; Lithoth. Adriat. Meer. in Wissensch. Meeresuntersuch. vii. (1905) Helgoland, t. f. 1. figs. 7–9; Lithoth. in 'Siboga' Exp. n. lxi. livr. 18, p. 19, pl. 2. figs. 1–4.

f. SUBTILIS, Fosl.

L. c.

Shape and size of the branches corresponding to *Lithoth. fruticulosum* f. *clavulata*.

Syn. *Lithothamnion fruticulosum* f. *clavulata*, Fosl. Corall. in Fl. Koh Chang, in Bot. Tidsskr. xxiv. (1901) p. 17; Lithoth. Adriat. Meer. *l. c.* t. 1. figs. 16–17; Lithoth. in 'Siboga' Exp. *l. c.* pl. 2. figs. 5–9.

This alga has previously been referred to *Lithoth. fruticulosum*, which it resembles both in habit and as to the form and size of the conceptacles of sporangia,—apart, however, from the fact that these organs, as I have earlier observed, in *Lithoth. indicum* for the most part show a more even bottom with sharper corners than usual in *Lithoth. fruticulosum.* This is not, however, a well-defined character, as typical *Lithoth. fruticulosum* shows sometimes the same state of things as to these organs, and, on the other hand, specimens of *Lithoth. indicum* occur, especially feebly developed ones, in which the conceptacles in a median-vertical section now and then show nearly the same form as in *Lithoth. fruticulosum.* As to the cystocarpic conceptacles, I remarked in Lithoth. Mald. & Laccad. *l. c.*, that the only point of difference from *Lithoth. fruticulosum* "appears to be the fact that the conceptacles of crystocarps are more acute than generally seen in specimens from the region last named" (the Mediterranean and the Adriatic). The specimens in which these organs were found corresponded, however, with a rather delicate and not well developed f. *clavulata.* Therefore I could attach no special importance to this character. In 'Siboga' Exp. n. lxi. p. 22, I also mentioned a form in which I found a few cystocarpic conceptacles which proved a little diverging from those of typical *Lithoth. fruticulosum.* But these specimens also were not well developed, in part even quite stunted and bearing only one or two of the organs in question. I have not till quite recently succeeded in finding them well developed and occurring in some

numbers in typical specimens from Australia, and less well developed and scanty in specimens from Providence. They diverge from the same organs in *Lithothamnion fruticulosum* by being almost superficial and conic or almost conic, always more pointed than in the latter species. They are finally quite dissolved, and thus they are not overgrown by new-formed tissue, as is often the case in *Lithoth. fruticulosum*. Accordingly I must consider the Indian and Pacific forms as independent species.

In the area in question *Lithoth. indicum* occurs in comparatively great depth. But it is generally smaller and not so vigorous and well developed as, *e. g.*, in Port Philip Bay, on the south coast of Australia, where it seems to be abundant in a depth of 2–5 fathoms. Thus at Cargados Carajos and at Providence it attains to a size of only about 4 cm. Here it bears sporangia in the months of August and September. In the former of these localities it occurs scantily in a depth of 30 fathoms, partly associated with *Lithoth. australe*, but particularly with rather numerous indeterminable and mostly dead calcareous algæ, in part attached to shells of mussels. At Providence it also occurs in a depth of about 30 fathoms and in rather large numbers. Here it has also been picked up from a depth of 50–78 fathoms, though only a few certain specimens together with some uncertain and indeterminable ones. From Amirante has been brought home an uncertain specimen, and from the Seychelles have been brought home two specimens not well developed.

Localities. Indian Ocean: Cargados Carajos, No. B 8 (30 fathoms), No. B 9 (30 fathoms), No. B 13 (30 fathoms), No. B 14 (30 fathoms); Providence, No. D 3 (29 fathoms), No. D 4 (50–78 fathoms), No. D 24 (30 fathoms); Amirante, No. E 13 (20–25 fathoms), uncertain; the Seychelles, No. F 2 (31 fathoms) (*Stanley Gardiner*).

Area. Mauritius; the Maldives; the south coast of Australia (Port Philip Bay); and several places in the Pacific Ocean, particularly the Malay Archipelago.

3. Lithothamnion gibbosum, Fosl.

Kgl. Norske Vidensk. Selsk. Skrift. 1906, n. 8 (1907), p. 7 (in Norwegian).

Thallus freely developed at the bottom, roundish, 1·5–4 cm. in diameter; branches subdichotomous, radiating from the centre, short, frequently crowded, partly rather anastomosing, partly not, subfastigiate, upper parts irregularly roundish-thickened or subcompressed, knotty, 2–7 mm. thick, smooth, and feebly shining; conceptacles of sporangia convex, but little prominent, 400–650 μ in diameter; sporangia unknown.

f. parvula, Fosl.

L. c.

Thallus 1·5–2 cm. in diameter, branches 2–3 mm. thick.

f. crassa, Fosl.

L. c.

Thallus 3–4 cm. in diameter, branches 4–7 mm. thick.

In a median section of a branch the medullar hypothallic cells are mostly 18–25 μ or up to about 30 μ long, and 11 (9)–14 μ broad. The perithallic cells are partly vertically

elongated, 11–18 or up to 22 μ long, and 9–11 or up to 14 μ broad, partly and chiefly in the external layers often subsquarish, about 9 μ in diameter, here and there a little horizontally elongated. The cells, as a general rule, are rather thick-walled, in part forming layers of tissue rather strongly defined.

The form *parvula*, which possibly represents the typical form of the species, bears in habit a considerable resemblance to small specimens of *Lithophyllum racemus* f. *typica*. It also approaches certain forms of *Lithoth. fruticulosum*, but the surface is smoother and, at any rate partly, feebly shining. The alga is freely developed on the bottom; but when it comes into contact with other calcareous algæ or other detached objects it partly develops a feeble crust, like several other species (*cf.* 'Siboga' Exp. n. lxi. p. 41).

Of the form *crassa* only a single specimen was found, which had also been lying loose at the bottom. In habit this form somewhat approaches *Lithoth. brachycladum* from the West Coast of Africa, *Lithoth. validum* from the Pacific Coast of North America, and *Lithoth. floridanum* from Florida, a group of species distinguished by coarse and short branches. Also as to structure it comes near to the species last mentioned.

In this respect it also, as well as f. *parvula*, approaches *Lithoth. indicum*. The form in question bears a great resemblance in habit to certain forms of *Arch. erythræum* (*cf.* 'Siboga' Exp. n. lxi. pl. 5. figs. 8, 9).

In both forms a partial decortication of the external layers of tissue of the branches occurs here and there rather closely recalling dissolved sori of sporangia of *Archæolithothamnion*.

Only the single specimen of f. *crassa* bears a few conceptacles of sporangia. The conceptacles finally, at any rate now and then, become overgrown by new-formed tissue, and are in a median-vertical section rather flat-bottomed with corners in part scarcely rounded. A few specimens of f. *parvula* show scars from dissolved conceptacles.

The species occurred at a depth of 55 fathoms, associated with *Lithoth. australe* and Squamariacea.

Locality. Indian Ocean: Saya de Malha, No. C 15 (*Stanley Gardiner*).

4. Lithothamnion australe, Fosl.

Lithothamnion coralloides f. *australis*, Fosl. Norw. Lithoth., in Kgl. Norske Vidensk. Selsk. Skrift. 1894 (1895), p. 92, ex parte; New or Crit. Lithoth., *l. c.* 1899, n. 5 (1900), p. 8, figs. 6–7.

Lithothamnion australe, Fosl. Rev. Syst. Surv. Melob., *l. c.* 1900, n. 5, p. 13; 'Siboga' Exp. n. lxi. livr. 18, p. 24, pl. 2. figs. 10–62.

As to the rather uncertain circumscription of this species and its varying forms, I refer to my remarks in 'Siboga' Exp. *l. c.* Also the specimens collected by Mr. Stanley Gardiner are sterile. Besides there are often developed thin crusts round specimens that are wholly or partly dead, and it is impossible to decide whether these crusts are new layers of accretion issuing from the part of the alga still living or, when the specimen is wholly dead, may represent young crusts of the same or another species.

The form occurring at Saya de Malha is most nearly connected with f. *tualensis*, in part, however, coarser than typical specimens of that form. There are also some finely branching specimens which very nearly approach f. *minutula* and are perhaps

identical with that form. Here the species occurs rather abundantly, particularly associated with *Lithoth. gibbosum* and numerous fragmentary undeterminable specimens. At Cargados Carajos it occurs in a form which partly also approaches f. *brachiata*, and some specimens are almost always consistent with typical f. *minutula*.

Localities. Cargados Carajos, No. B 8 (30 fathoms), No. B 14 (30 fathoms); Saya de Malha, No. C 15 (55 fathoms) (*Stanley Gardiner*).

Area. Several places in the Pacific Ocean, particularly the Malay Archipelago.

Genus ARCHÆOLITHOTHAMNION (Rothpl.), Fosl.

5. ARCHÆOLITHOTHAMNION ERYTHRÆUM (Rothpl.), Fosl.

Rev. Syst. Surv. Melob., in Kgl. Norske Vidensk. Selsk. Skrift. 1900, n. 5, p. 8.
Lithothamnion erythræum, Rothpl. in Bot. Centralbl. liv. (1893) p. 5.

Of this species only a single specimen occurs, feebly developed, attached to a piece of coral and coalesced with another calcareous alga which is undeterminable.

It was picked up from a depth of 26 fathoms, apparently in company with *Lithoph. Okamurai*.

Locality. Saya de Malha, C 16 (*Stanley Gardiner*).

Area. The Red Sea; the Gulf of Aden; the Maldives, and many places in the Pacific Ocean.

6. ARCHÆOLITHOTHAMNION TIMORENSE, Fosl.

'Siboga' Exp. n. lxi. livr. 18, p. 42, pl. 8. figs. 1–11.

Of the above species three specimens were brought home, which most nearly resemble figs. 4 and 11, *l. c.* They were dredged at a depth of 31 fathoms and provided with sporangia in October.

Locality. The Seychelles, No. F 2 (*Stanley Gardiner*).

Area. Timor and a few other places in the Pacific Ocean.

Tribe MELOBESIEÆ, Aresch. (mut. char.).

Genus GONIOLITHON, Fosl.

Subgenus EUGONIOLITHON, Fosl.

7. GONIOLITHON FRUTESCENS, Fosl.

Calc. Alg. Funafuti, in Kgl. Norske Vidensk. Selsk. Skrift. 1900, n. 1, p. 9.

The forms of this species occurring on the reefs of the Salomon and Egmont Atolls in the Chagos Archipelago and at Coetivy are generally more finely branching than at Funafuti, the place where the alga was first found. In this respect they are most closely connected with the forms from the Malay Archipelago figured in 'Siboga' Exp. n. lxi. pl. 10, but they are mostly more densely branching. On the other hand, a couple of small specimens from a lagoon shoal at Egmont are of about the same coarseness as

those from Funafuti, though more densely branching than the typical form as it appears at Funafuti and at the Maldives (*cf.* Fosl. Lithoth. in Gardiner, Mald. & Laccad. i. pl. 25. fig. 4)*. The species is probably more densely branched, the more exposed the locality is in which it is growing. Almost all the specimens collected are so far most nearly connected with f. *congesta* (*cf. op. c.* pl. 25. figs. 5, 6). Several of them, however, bear branches compressed or flabellate, for which reason they are to be referred to f. *flabelliformis*, though they are not wholly consistent with typical specimens of this form. Besides, some specimens approach much more to f. *subtilis* (*cf.* 'Siboga' Exp. n. lxi. pl. 10. figs. 12, 13). *Gon. frutescens* thus proves to be a species varying much, like many other calcareous algæ. This is no doubt partly due to local conditions.

The alga appears to have grown in association with *Lithoph. Gardineri*, several of the specimens brought home having been accrete with that species or with corals. It probably occurs in large numbers, particularly at the Salomon Atoll and at Coetivy. At the former locality and at Egmont Atoll it seems for the most part to be sterile in the months of May and June, while some are richly fructifying at Coetivy in September.

Localities. Chagos Archipelago; Salomon Atoll, reef; Egmont Atoll, reef and lagoon shoal; Coetivy, E. reef and other places (*Stanley Gardiner*).

Area. The Maldives and Laccadives, and some places in the Pacific Ocean.

Genus Lithophyllum, Phil. (emend.).

Subgenus Eulithophyllum, Fosl.

8. Lithophyllum Okamurai, Fosl.

Five new Calc. Alg., in Kgl. Norske Vidensk. Selsk. Skrift. 1900, n. 3, p. 4.

f. ptychoides, Fosl.

Kgl. Norske Vidensk. Selsk. Skrift. 1906, n. 8 (1907), p. 29 (in Norwegian).

This form is nearly connected with f. *trincomaliensis* from Ceylon, but diverges from it by being less branching and by having partly smaller cells. The specimens are rather encumbered with extraneous objects and particularly much attacked by worms. In consequence they are somewhat stunted and bear conceptacles sparsely. Also the conceptacles have been attacked by organisms, and consequently sporangia are not to be found. Conceptacles overgrown by new-formed tissue, on the other hand, occur in rather large numbers.

The forms hitherto known of *Lithoph. Okamurai* occur in the littoral region or in shallow water, whereas f. *ptychoides* is found in a depth of about 26 fathoms.

Locality. Saya de Malha, No. C 16 (26 fathoms), and No. C 19 (29 fathoms), uncertain (*Stanley Gardiner*).

Area. Ceylon, and several places in the Pacific.

* J. Stanley Gardiner, 'The Fauna and Geography of the Maldive and Laccadive Archipelagoes,' vol. i. part 4.

9. LITHOPHYLLUM KAISERI, Heydr.

Lithothamnion Kaiserii, Heydr. in Ber. Deutsch. bot. Ges. xv. (1897) p. 64.
Lithophyllum Kaiserii, Heydr. *l. c.* p. 412.

f. TYPICA.

Lithophyllum Kaiserii, Heydr. in Ber. Deutsch. bot. Ges. xv. (1897) p. 412.

f. SUBPLICATA, Fosl.

Vidensk. Selsk. Aarsber. for 1900, p. 14.
Syn. *Lithophyllum madagascarense*, Heydr. Nouv. Mélob., in Bull. Mus. Hist. Nat. Par. viii. (1902) p. 473.

As I have already pointed out, it is scarcely possible to draw a line between *Lithoph. Kaiseri* and *Lithoph. pallescens*, Fosl., the latter occurring in the Gulf of California. The same is the case with *Lithoph. affine*. It proves more and more evident that both *L. Kaiseri* and *L. affine* must be sunk under *Lithoph. pallescens*, while, on the other hand, this species is very nearly allied to *Lithoph. racemus* and *Lithoph. Okamurai*. I do not unite them here, as I must first go over the material, now somewhat increased, which I have not yet had an opportunity of doing. Also *Lithoph. madagascarense*, Heydr. *, must be referred to the same species. According to the type specimen, which by the kindness of Mr. P. Hariot I have had the opportunity of examining, it only represents a coarse f. *subplicata*.

The specimens collected are rather well developed and up to about 8 cm. in diameter; but they are partly burdened with other algæ which have attached themselves to them. They belong partly to the typical form of the species, partly to f. *subplicata*. In the month of November they bore ripe sporangia.

Locality. The Seychelles Archipelago: Praslin Island, reef (*Stanley Gardiner*) †.

Area. Madagascar, Réunion, Mauritius, and Rodriguez; the Red Sea; the Maldive and the Laccadive groups; Cocos-Keeling Island; and some places in the Pacific Ocean.

10. LITHOPHYLLUM MOLUCCENSE, Fosl.

On some Lithoth., in Kgl. Norske Vidensk. Selsk. Skrift. 1897, n. 1, p. 12; Calc. Alg. Funafuti, *l. c.* 1900, n. 1, p. 10; New Melob., *l. c.* 1900, n. 6 (1901), p. 12; 'Siboga' Exp. n. lxi. livr. 18, p. 67, pl. 12. figs. 2–13.

Of this species there have been brought home but two small specimens, rather feebly developed, attached to pieces of corals. One of them is most nearly connected with f. *pygmæa*, and the other belongs to f. *flabelliformis*. The alga was furnished with ripe sporangia in the month of November.

Locality. The Seychelles Archipelago: Praslin Island, reef (*Stanley Gardiner*).

Area. Mauritius, and several places in the Pacific Ocean.

* F. Heydrich, "Quelques nouvelles Mélobésiées du Museum d'Histoire Naturelle de Paris," Bulletin du Museum d'Histoire Naturelle, viii. (1902) p. 473.

† Also collected by the German 'Valdivia' Expedition at Mahé (*Lithoph. affine*) and at Diego Garcia (*Lithoph. Kaiseri*).

Subgenus Porolithon, Fosl.

11. Lithophyllum onkodes, Heydr.

Ber. der Deutsch. bot. Ges. xv. (1897) p. 410.

Lithothamnion onkodes, Heydr. Neue Kalkalg. (1897) p. 6, partim (Bibl. Bot. vii. Heft 41).

This no doubt important reef-builder occurs in the Chagos Archipelago and at Coetivy in an unusually vigorously developed form. It forms massive and more or less uneven crusts, and probably covers the reefs to a considerable extent. It often also incrusts other objects and on the whole rather varies in shape. Thus it sometimes even forms small cap-shaped coverings on the apices of branches of corals. The species is generally of very firm consistency, and therefore rather heavy proportionately to the size.

At Salomon Atoll it was also picked up from a depth of 10–14 fathoms in the lagoon, incrusting shells of mussels or pieces of coral, but the specimens, however, are small and feebly developed. It is not known whether specimens vigorously developed occur at this depth.

In Lithoth. Mald. & Laccad. p. 468, I mentioned that in a vertical section of some of the crusts "the cells are here and there larger than is generally found, more regular, and with their longest diameter in a vertical direction." This is also in part the case with the specimens in hand. In several of the most vigorously developed ones the cells also form here and there rather distinct layers of tissue, sometimes even irregularly alternating short and long cells. Frequently small groups of enlarged cells are numerous.

Old specimens of this species are mostly sterile, but younger ones are provided with reproductive organs in the months of May and June at Salomon and Egmont Atolls, and at Coetivy in September.

Localities. Chagos Archipelago: Salomon Atoll, reef, and lagoon 10–14 fathoms; Egmont Atoll, reef; Coetivy, W. reef (*Stanley Gardiner*).

Area. The Mauritius; the Maldives and Laccadives; Ceylon; and widely dispersed in the Pacific Ocean.

12. Lithophyllum craspedium, Fosl.

New or Crit. Calc. Alg., in Kgl. Norske Vidensk. Selsk. Skrift. 1899, n. 5 (1900), p. 26; Lithoth. in Gardiner, Mald. & Laccad. i. p. 466, pl. 25. figs. 1, 2.

This species also appears to be an important reef-builder, forming, when most vigorously developed, sometimes almost columnar masses with coarse branches. The specimens brought home partly belong to the typical form of the species with branches almost terete, but rather anastomosing, with transitions to f. *compressa*, partly to f. *abbreviata* with smaller and shorter branches.

As is remarked below under *Lithoph. Gardineri*, the latter and *Lithoph. craspedium* are closely connected with each other, though *Lithoph. craspedium* is in general much coarser and a more vigorously developed alga. There are, however, cases in which they are with certainty distinguishable only by their anatomic structure. In *Lithoph. Gardineri*, in a median section of a branch, the medullar hypothallic cells prove to

alternate, forming one row of short cells and two or four or sometimes up to seven rows of long ones. Also in *Lithoph. craspedium* the cells are alternately short and long, but the latter form only one or two, sometimes three, rows. The short cells in the species in question are subquadrate or vertically elongated, 9–14 μ long and 7–11 μ broad, the long ones 18–22, sometimes up to 29 by 7–11 μ. The perithallic cells are subquadrate, elongated vertically or horizontally, 7–11 μ, or up to 14 μ long in a vertical direction. Short groups of enlarged cells are frequently numerous.

The alga appears to occur most abundantly in the Chagos Archipelago, but it is found well developed also at Coetivy. It bears reproductive organs in the months of May, June, and September, but old specimens are, as usual, almost always sterile.

Localities. The Chagos Archipelago: Salomon Atoll, reef; Egmont Atoll, reef and reef-edge; Coetivy, E. reef.

Area. The Maldives and Laccadives; and the Ellice Islands (Funafuti) in the Pacific Ocean.

13. Lithophyllum Gardineri, Fosl., sp. n.

Kgl. Norske Vidensk. Selsk. Skrift. 1906, n. 8 (1907), p. 30 (in Norwegian).

Thallus forming masses partly and most frequently densely, partly somewhat spreadingly branching, 3–5 cm. high and 4–10 cm. in diameter, attached at a younger stage by a crust-like hypothallus 1–3 mm. thick, at an older stage the hypothallus often almost disappearing; branches repeatedly subdichotomous, frequently rather anastomosing, sometimes forming in the basal part an almost solid mass, subfastigiate, terete or subcompressed, short or somewhat elongated, straight or somewhat curved, knotty or here and there developing short side-branches, 2·5–4, seldom up to 5 mm. thick, feebly tapering and rounded, or the apices roundish-thickened; conceptacles of sporangia convex, but little prominent, 240 (200)–360 μ in diameter; sporangia four-parted, 50–70 μ long and 30–40 μ broad (Pl. 15. figs. 1–4).

f. subhemisphærica, Fosl., f. n.

Thallus almost hemispherical, about 15 cm. high and 22–25 cm. in diameter; branches crowded and rather anastomosing, subfastigiate, short and rather curved, knotty, 2–3 mm. thick, with the apices rounded or subtruncate and sometimes depressed in the centre (Pl. 16).

f. obpyramidata, Fosl., f. n.

Thallus more or less obpyramidal, 4–6 cm. in diameter; branches frequently much anastomosing, subterete or compressed, with the apices roundish-thickened or subtruncate, often depressed in the centre, or irregularly dilated upwards and retuse (Pl. 15. figs. 5–8).

The typical form of this species, which I have named in honour of Mr. Stanley Gardiner, approaches in habit certain and particularly coarse forms of *Lithoph. Kaiseri* (*cf.* Pl. 15. figs. 1, 2, and Lithoth. in Mald. & Laccad. i. pl. 24. fig. 5). It is,

however, essentially, different from that species, peculiarly in structure. It is actually most nearly connected with *Lithoph. craspedium.* This is particularly the case with f. *obpyramidata*, which is sometimes hardly distinguishable from a *Lithoph. craspedium* f. *abbreviata* feebly developed, the latter sometimes showing as thin branches as those of f. *obpyramidata*. In structure, however, there is some difference between the two species, as the medullar hypothallic cells of *Lithoph. craspedium* form a row of short cells, rather regularly alternating with one or two or up to three rows of long ones, whereas in the species in question the corresponding long cells, as above mentioned, frequently form more rows. When these rows of elongated cells occur in numbers of six to seven, a longitudinal section sometimes gives the impression of a faint cup-shaped stratification, as is usual particularly in branching species of the genus *Lithothamnion*. The form *subhemisphærica* is vigorously developed and much larger than any of the other forms. The branches are a little thinner, more crowded, and more curved than is usual in the typical form. A single specimen only of this form is known from the reef of Egmont Atoll. There are also forms of *Lithoph. Gardineri* which bear in habit rather close resemblance to *Lithoph. craspedium* f. *subtilis*. The latter, however, is a form as yet insufficiently known, which may perhaps represent a separate species, but, being in structure in all essentials consistent with *Lithoph. craspedium*, is for the present to be regarded as a feebly developed or stunted form of this species.

Lithoph. Gardineri seems to occur abundantly on reefs, and particularly associated with *Lithoph. craspedium* and *Goniolithon frutescens*, sometimes coalescing especially with the species last mentioned. Specimens are also found coalesced with corals. No doubt it is an important reef-builder, though perhaps less so than *Lithoph. craspedium* and *Lithoph. onkodes*. The species seems to occur most numerously and best developed in the Chagos Archipelago, particularly on the reefs. Small specimens have been brought home from "Nullipore shoal in lagoon" of Egmont Atoll. However, it is also found well developed at Coetivy. But some of the specimens brought home from this locality have no doubt grown under conditions different from those at Salomon Atoll, partly appearing as a well-defined f. *obpyramidata*.

The species is scantily furnished with ripe sporangia in the month of September. Most of the specimens collected on Salomon Atoll in May–June are sterile or provided with empty conceptacles.

Localities. Chagos Archipelago: Salomon Atoll, reef, f. *typica*, f. *obpyramidata*; Egmont Atoll, reef and lagoon shoal, f. *typica*, f. *subhemisphærica*, f. *obpyramidata*; Coetivy, E. reef and other localities, f. *typica*, f. *obpyramidata* (*Stanley Gardiner*).

EXPLANATION OF THE PLATES.

All the figures from photographs about $\frac{3}{4}$ natural size.

Plate 15.

Lithophyllum Gardineri, Fosl., f. *typica.*

Figs. 1–3. Specimens from Salomon Atoll, Chagos.

Fig. 4. A rather young specimen attached to a fragment of a decaying root: Coetivy.

Lithophyllum Gardineri, Fosl., f. *obpyramidata.*

Fig. 5. A specimen forming a transition to the typical form: Salomon Atoll, Chagos.

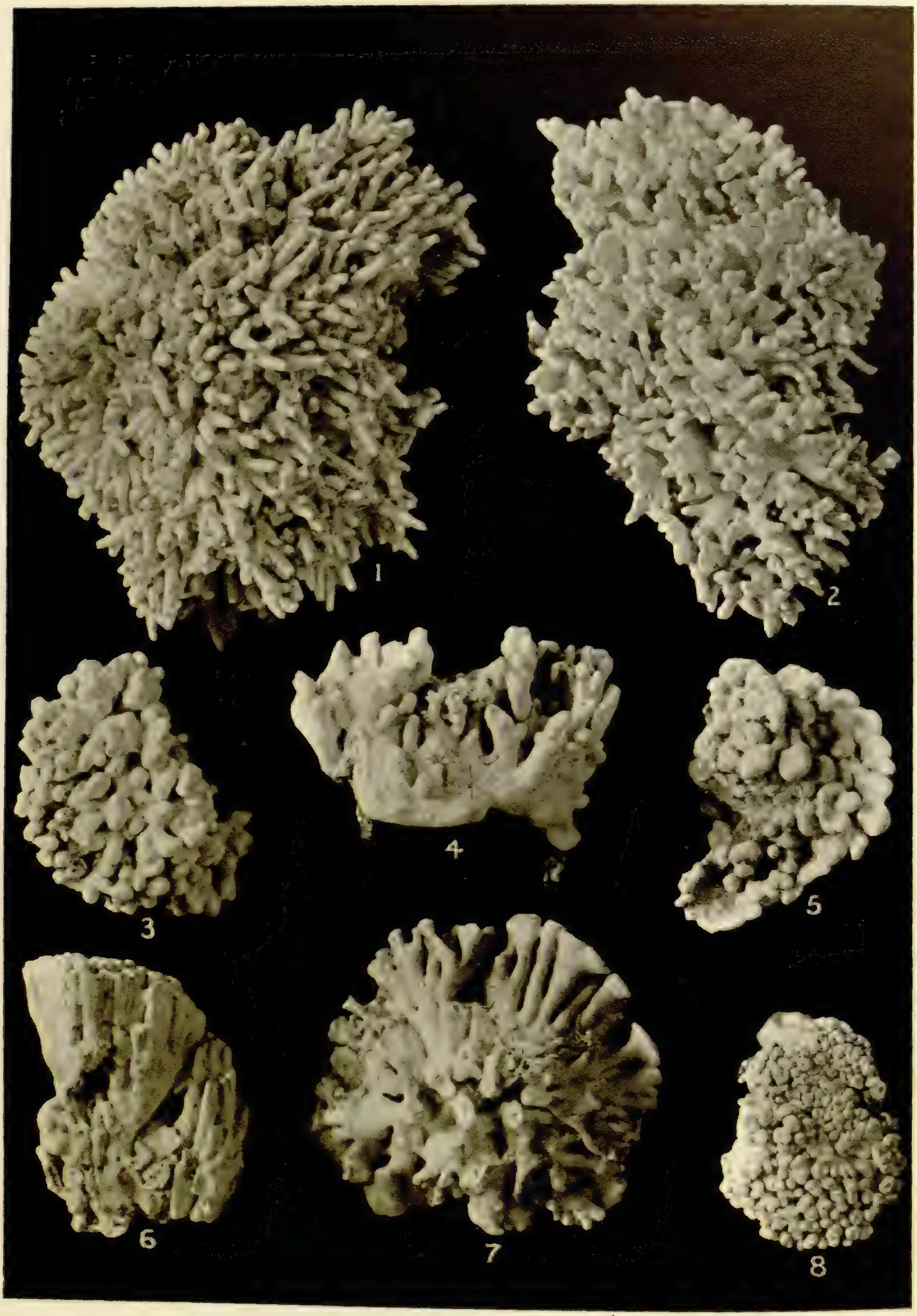
Figs. 6, 8. Specimens with much anastomosing and in part rather delicate branches: Egmont Atoll, Chagos.

Fig. 7. A specimen seen from below, with the outer branches partly rather dilated at their ends: Coetivy.

Plate 16.

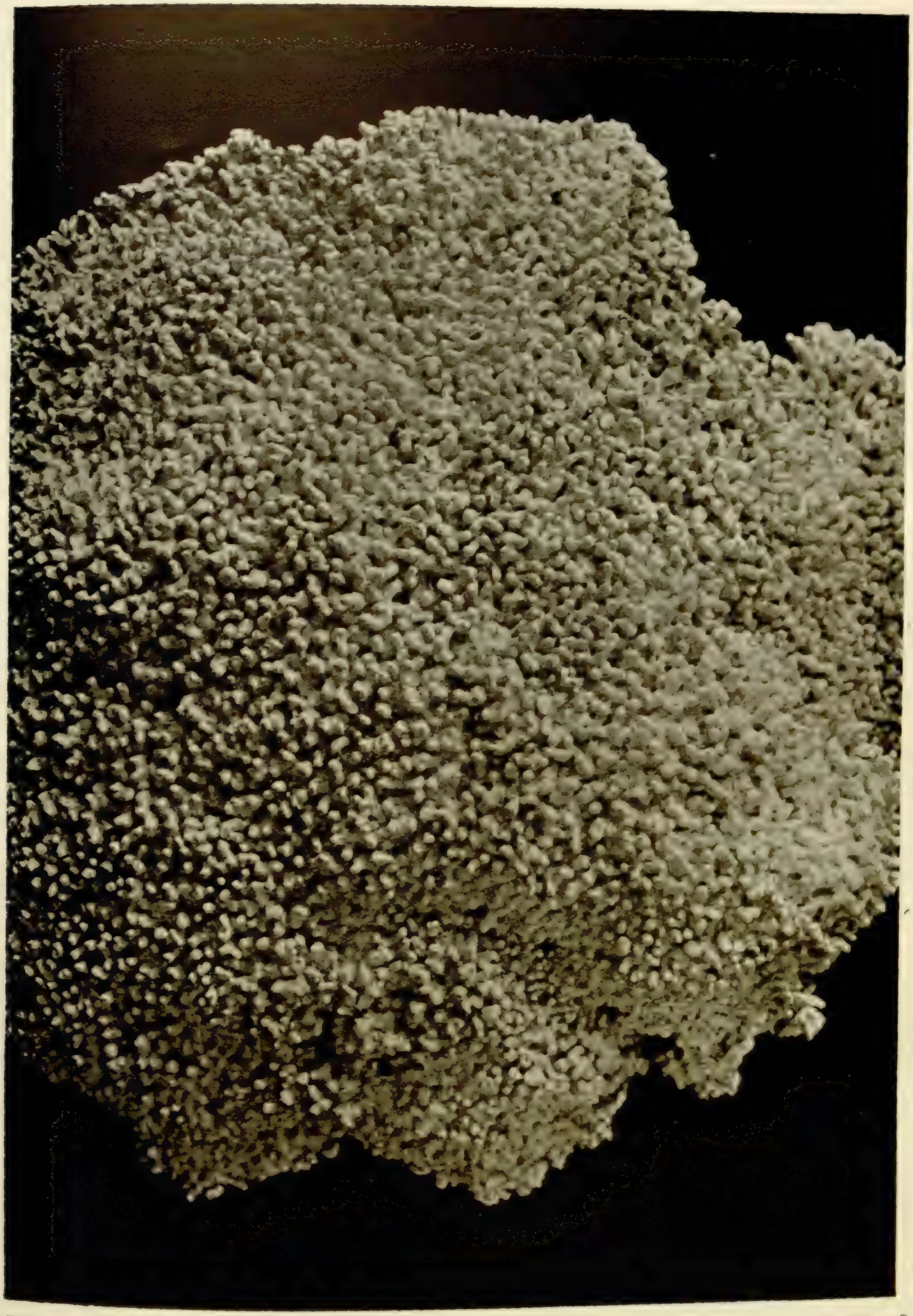
Lithophyllum Gardineri, Fosl., f. *subhemisphærica.*

Part of the alga seen from above: Egmont Atoll, Chagos.



M. Foslie photo. Grout Engr. Co.

LITHOPHYLLUM GARDINERI, Fosl.



M. Foslie photo. Grout Engr. Co.

LITHOPHYLLUM GARDINERI, Fosl.

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8s. to the public, and 6s. to Fellows; to Vols. 26–30, 4s. to the public, and 3s. to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

Second Series.—Botany.

Volume.		When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
I.	Part I.	1875.	0	8	0	0	6	0
	Part II.	1875.	0	16	0	0	12	0
	Part III.	1876.	0	12	0	0	9	0
	Part IV.	1876.	0	10	0	0	7	6
	Part V.	1878.	1	4	0	0	18	0
	Part VI.	1879.	1	6	0	0	19	6
	Part VII.	1880.	1	4	0	0	18	0
	Part VIII.	1880.	1	1	0	0	16	0
	Part IX.	1880.	1	0	0	0	15	0
II.	Part I.	1881.	0	12	0	0	9	0
	Part II.	1882.	0	5	0	0	3	9
	Part III.	1883.	0	10	0	0	7	6
	Part IV.	1883.	0	3	0	0	2	3
	Part V.	1883.	0	3	0	0	2	3
	Part VI.	1884.	0	13	6	0	10	0
	Part VII.	1884.	0	9	6	0	7	0
	Part VIII.	1884.	0	10	0	0	7	6
	Part IX.	1886.	0	7	0	0	5	0
	Part X.	1887.	0	3	4	0	2	6
	Part XI.	1886.	0	6	0	0	4	6
	Part XII.	1886.	0	8	0	0	6	0
	Part XIII.	1887.	1	7	0	1	0	0
	Part XIV.	1887.	0	7	0	0	5	0
	Part XV.	1887.	0	10	0	0	7	6
	Part XVI.	1888.	0	2	6	0	2	0
III.	Part I.	1888.	3	12	0	2	14	0
	Part II.	1891.	0	5	0	0	3	9
	Part III.	1891.	0	7	0	0	5	0
	Part IV.	1891.	[illegible]	6	0	0	4	6
	Part V.	1891.	0	6	0	0	4	6
	Part VI.	1891.	0	3	6	0	2	8
	Part VII.	1892.	0	6	0	0	4	6
	Part VIII.	1893.	0	6	0	0	4	6
	Part IX.	1893.	1	8	0	1	1	0
	Part X.	1894.	0	10	0	0	7	6
	Part XI.	1894.	0	3	4	0	2	6

Second Series.—Botany (*continued*).

Volume.		When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
IV.	Part I.	1894.	1	0	0	0	15	0
	Part II.	1894.	2	0	0	1	10	0
	Part III.	1895.	2	10	0	1	17	6
	Part IV.	1895.	0	3	4	0	2	6
V.	Part I.	1895.	0	9	0	0	6	9
	Part II.	1895.	0	12	0	0	9	0
	Part III.	1896.	0	6	0	0	4	6
	Part IV.	1896.	1	0	0	0	15	0
	Part V.	1896.	0	14	0	0	10	6
	Part VI.	1896.	0	4	0	0	3	0
	Part VII.	1897.	0	4	0	0	3	0
	Part VIII.	1897.	0	6	0	0	4	6
	Part IX.	1899.	0	12	0	0	9	0
	Part X.	1899.	0	6	0	0	4	6
	Part XI.	1899.	0	7	0	0	5	0
	Part XII.	1899.	0	12	0	0	9	0
	Part XIII.	1900.	0	1	6	0	1	2
	Part XIV.	1900.	0	3	0	0	2	3
	Part XV.	1901.	0	6	0	0	4	6
VI.	Part I.	1901.	1	10	0	1	2	6
	Part II.	1901.	0	6	0	0	4	6
	Part III.	1902.	0	18	0	0	13	6
	Part IV.	1903.	0	8	0	0	6	0
	Part V.	1903.	0	8	0	0	6	0
	Part VI.	1903.	0	12	0	0	9	0
	Part VII.	1904.	0	12	0	0	9	0
	Part VIII.	1904.	0	12	0	0	9	0
	Part IX.	1904.	0	7	0	0	5	3
	Part X.	1904.	0	14	0	0	10	6
	Part XI.	1905.	0	4	0	0	3	0
VII.	Part I.	1904.	0	5	0	0	3	9
	Part II.	1905.	0	6	0	0	4	6
	Part III.	1906.	0	3	0	0	2	3
	Part IV.	1906.	0	7	0	0	5	3
	Part V.	1907.	0	10	0	0	7	6
	Part VI.	1907.	0	4	0	0	3	0

2nd Ser. BOTANY.] [VOL. VII. PART 7.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

ON TRIASSIC SPECIES OF THE GENERA ZAMITES AND PTEROPHYLLUM: TYPES OF FRONDS BELONGING TO THE CYCADOPHYTA.

BY

E. A. NEWELL ARBER, M.A., F.L.S., F.G.S.,

TRINITY COLLEGE, CAMBRIDGE; UNIVERSITY DEMONSTRATOR IN PALÆOBOTANY.

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

November 1907.

VII. *On Triassic Species of the Genera* Zamites *and* Pterophyllum: *Types of Fronds belonging to the Cycadophyta.*

By E. A. Newell Arber, *M.A., F.L.S., F.G.S., Trinity College, Cambridge; University Demonstrator in Palæobotany.*

(Plates 17–19.)

Read 20th June, 1907.

Contents.

	Page
Introduction	109
Zamites grandis, nom. nov.	111
The Genus *Zamites*	111
The Species *Zamites grandis*, nom. nov.	113
(1) Synonymy, Localities, and Diagnosis	113
(2) Description of the Specimens	114
(3) Affinities of the Species	115
Pterophyllum Bronni, Schenk	119
The Genus *Pterophyllum*	119
The Species *Pterophyllum Bronni*, Schenk	120
(1) Synonymy, Locality, and Diagnosis	120
(2) Description of the Specimen	120
(3) Affinities of the Species	121
General Conclusions	124
Bibliography	125
Explanation of the Plates	127

Introduction.

It is now a thoroughly established fact that the general aspect of the Mesozoic vegetation of the Rhætic, Jurassic, and Lower Cretaceous rocks differed entirely from that of the Palæozoic floras. In recent years our knowledge of the various representatives of plant life which succeeded one another during these two great epochs has been so greatly advanced that we are now in a position to inquire into the nature of the change from the older, Palæozoic, to the newer, Mesozoic, facies. Was it, on the whole, abrupt—a sudden transformation—or was it gradual and imperceptible? In the latter case we should expect to discover evidence of a well-marked transition flora, composed partly of old, partly of new types.

In this connection it is interesting to find that we can trace back the first incomings of several of the more important Mesozoic races to sediments of Palæozoic age. It seems clear that some at least of these groups, especially the Cycadophyta, which in Mesozoic times attained to the position of ruling or dominant races, did not spring into existence suddenly. The advent of the Cycadophyta is foreshadowed in both the Carboniferous

and Lower Permian rocks, and, to a greater extent, in the sediments lying between the Permian and Rhætic deposits. During Palæozoic times, however, other and older types of vegetation were dominant, while the Cycadophyta were as yet in the infancy of their development and formed a subsidiary group; a fact which is emphasised by their infrequent occurrence and lack of diversity.

Omitting from the list Gœppert's * *Cycadites taxodinus*, from the Lower Carboniferous (Culm) of Silesia, as founded on too imperfect evidence to be regarded as a satisfactory representative of the group, we find in the Upper Carboniferous of the Northern Hemisphere leaf-impressions of several members of the Cycadophyta, all which, however, are very rare as compared with other genera belonging to typical Palæozoic races. The fronds known as *Pterophyllum*, a large genus and one of the earliest to attain to the dominant phase in Mesozoic times, more especially in the Keuper and Rhætic periods, is known from the Westphalian division of the Coal Measures of France † and from the Upper Carboniferous and Permian of Germany ‡.

The genus *Nœggerathia*, a name now applied in a restricted sense, is exclusively Westphalian in age. The attribution of this genus to the Cycadophyta is, however, doubtful §. Other genera, such as *Zamites* ‖ and *Plagiozamites* ¶, also appear on this horizon in the coalfield of Commentry, in France, and the latter also in beds of the same age in the Vosges. Zalessky ** has recently shown that *Plagiozamites* is associated in Manchuria with a Stephanian flora. The genus *Sphenozamites* †† appears first in the Lower Permian near Autun, in France.

In the Permo-Carboniferous flora of India and the Southern Hemisphere (Glossopteris flora), a *Pterophyllum* of the subgroup *Anomozamites* is known, as well as a specimen doubtfully referred to the genus *Cycadites* ‡‡.

Thus we see that a large number of the more important frond-genera of Cycadophyta are now known from the Palæozoic rocks, though others, such as *Podozamites*, *Otozamites*, and *Dioonites*, have so far not been found in formations older than the Mesozoic period.

In the present communication two very interesting fronds are discussed, one belonging to the genus *Zamites*, recorded now from both the Bunter and Keuper divisions of the Trias, and for the first time from British rocks; the other, provisionally referred to the genus *Pterophyllum*, from the Keuper rocks of Carinthia. Both these leaves have been previously described on several occasions, and, as we have seen, these genera have been already recognised from sediments of Palæozoic age. These particular species, however, have been the cause of much perplexity and confusion in the past. Both the fossils

* Goeppert (1866), p. 131, pl. 2. figs. 1–3.

† Zeiller & Renault (1888), p. 619, pl. 68. fig. 1; Renault & Zeiller (1886), p. 326.

‡ See Solms-Laubach (1891), p. 85.

§ See Solms-Laubach (1891), pp. 141 and 151.

‖ Renault & Zeiller (1886), p. 327; Zeiller & Renault (1888), p. 614, pl. 67. fig. 7.

¶ Zeiller (1894), p. 174, pl. 8. figs. 1–5, pl. 9. fig. 1; Zeiller & Renault (1888), p. 615, pl. 67. fig. 8.

** Zalessky (1905), p. 401, text-figs. 13–15.

†† Renault (1881[1]), (1881[2]), (1893), p. 327, pl. 81. fig. 1.

‡‡ Arber (1905), pp. 208–210.

have been regarded as Monocotyledonous leaf-impressions, and in the one case the same plant has been figured by different authors under totally distinct names, though almost invariably in the belief that its affinities lay with the same group. It will thus be found that the present consideration of *Zamites grandis* goes far to undermine the supposed evidence for the existence of Monocotyledons in the earlier Triassic epochs. It is also hoped that the present study will throw light on some of the earlier Mesozoic representatives of the Cycadophyta.

I would here express my thanks to my friend and pupil Mr. L. J. Wills, B.A., of King's College, Cambridge, who has made the important discovery of the first specimens of *Zamites grandis* from England *, for placing the material at my disposal for description.

I am greatly indebted to Professor Rothpletz, of Munich, for the loan of, and for permission to figure, the fine specimen of *Pterophyllum Bronni* described here, as well as for facilities for studying the collections in the Munich Museum.

I would also return my sincere thanks to Prof. Zeiller, of Paris; to Prof. Solms-Laubach and Prof. Benecke, of Strasburg; to Prof. E. Fraas and Dr. E. Schütze, of Stuttgart, and to Prof. Beckenkamp, of Würzburg, who have all most generously assisted me, either by allowing me free access to the collections under their care, or by other aids in connection with this and other studies of the comparatively little-known Triassic flora.

ZAMITES GRANDIS, nom. nov.

While the genus *Zamites* is known from the Palæozoic rocks, it has not hitherto been definitely recognised from the Trias, although it is a most abundant frond-type in the Rhætic, Jurassic, and Wealden formations. Only one fossil, and that, as we shall see (p. 115), of a very doubtful nature, has been recorded under this name from the Bunter of the Vosges. Renault and Zeiller † have called attention to the absence of any evidence of this type of frond in the Triassic rocks. On the contrary, as I hope to show here, Zamitean fronds have been frequently described and figured during the last 60 years, for rocks of this age in various parts of Europe, though under other names, and these Triassic fronds, which in my opinion should be included within this genus, possess certain peculiarities which have led most observers into error with regard to their real affinities.

The Genus ZAMITES, *Brongniart*, 1828.

1828. *Zamites*, Brongniart, Prodr. Hist. Végét. foss. p. 94.
1844. *Yuccites*, Schimper & Mougeot, Monogr. Plant. foss. Vosges, p. 42.
1870. *Macropterygium* (*pars*), Schimper, Traité, vol. ii. p. 132.
1870. *Yuccites* (*pars*), Schimper, *ibid.* p. 426.
1871. *Palæozamia*, Phillips, Geol. of Oxford, p. 169.
1873. *Yuccites* (*pars*), Zigno, Fl. foss. Form. Oolith. vol. ii. p. 7.
1891. *Yuccites* (*pars*), Saporta, Plantes Jurassiques, vol. iv. p. 69.

* Wills (1907).

† Renault & Zeiller (1886), p. 328.

1894. *Cordaites* (*non* Unger), Compter, Zeitschr. Naturwiss. Leipzig, vol. lxvii. p. 225.
1895. *Zamia*, Ward, 15th Ann. Rep. U.S. Geol. Surv. p. 350.
? 1903. *Nœggerathiopsis* (*non* Feistmantel), Zeiller, Flor. foss. Gîtes Charb. Tonkin, p. 149.

It will be necessary to briefly consider the significance attached to this generic name, since the attribution of the fossils described here forms the main point of this communication.

In the past there has been some difference of opinion as to whether certain fronds should be included or excluded from the genus *Zamites*, and the sense in which this term has been used by several authors has often been extremely vague. Brongniart * originally referred to the recent genus *Zamia* a fossil frond from the Kimmeridgian of France, now known as *Zamites Feneonis*, Brongn., which together with the British Jurassic frond *Z. gigas*, Lindl. & Hutt.†, may perhaps be regarded as among the more typical members of the genus. The term *Zamites*, also first instituted by Brongniart, was, however, applied by him to a subdivision of the living genus *Zamia*, and the same author included several fossils under it. It is now generally agreed that such a use of the name of a still existent genus cannot be justified, and consequently the term *Zamites* has been raised to generic rank. It has also been found that Brongniart's original definition required emendation, and several attempts have been made by different authors to construct a satisfactory generic diagnosis by a modification of his scheme, so as to give it a more exact significance and to make it capable of wider application. An excellent sketch of these proposals has been given by Prof. Seward ‡, and so the matter need not be referred to here at length.

The first really satisfactory diagnosis was that given by Schimper in 1870 in his 'Traité,' which may be quoted here *in extenso*, in view of the inclusion within this genus of the species described in this paper:—"Folia quoad formam et magnitudinem valde varia, nunc ex ovato-oblongo acuminata, nunc ex oblongo, nunc e lineali-oblongo acuminata, regulariter pinnata. Pinnæ plus minusve patentes nec rachi perpendiculariter insertæ, lanceolatæ, lineali-lanceolatæ, oblongæ, acuminatæ vel obtusæ, basi subito contracta plus minus distincte callosa rachis lateri anteriori adfixæ, solide coriaceæ, nervis sat distinctis strictis, inter se parallelis, ad folioli apicem cum hujus margine abruptis" §.

This diagnosis specifies several points to which I also attach importance, namely, the great variation in the size and form of the leaf exhibited by different species, the sudden nature of the contraction in the breadth of the pinna near its point of attachment, the presence of a more or less distinct basal callosity, and the strictly parallel and straight course of the nerves. Schimper further emphasises some of these peculiarities in the paragraph following the above extract in his book.

A more recent definition of Prof. Seward ‖ is as follows:—"Frond pinnate, pinnæ more or less obliquely inclined to the rachis and attached to the upper surface, apices

* Brongniart (1828), p. 94.

† Now referred to the genus *Williamsonia* of the group Bennettiteæ.

‡ Seward (1895), pp. 75–78.

§ Schimper (1869), vol. ii. p. 151.

‖ Seward (1895), p. 78.

acuminate and tapering or obtusely rounded, the base may be abruptly rounded and marked with a callosity near the point of attachment, or the pinnæ may be slightly and gradually narrowed towards the base, margins entire; veins parallel, but slightly divergent in the apical portion of each pinna."

This definition is of a somewhat wider nature than Schimper's, especially as regards the characters of the bases of the pinnæ. The author states, however, that "such a definition is perhaps suggestive of a genus with characters expressed in too general terms, and not sufficiently limited." Prof. Seward also lays great stress on the attachment of the pinnæ to the upper surface of the rachis, but even in species in which there is every reason to believe this is the case, it is a feature which is often very difficult to establish, and thus usually of slight value as a help towards a correct determination of the genus. Often when the rachis has been considerably flattened, and especially when the lower surface of the frond is viewed, the leaflets may appear to be attached laterally, though better specimens show that in reality such is not the case. In regard to the very species, *Zamites buchianus* (Ett.), to which Prof. Seward points as a fossil showing the true mode of attachment of the leaflets, there are many examples in the British Museum, and also in the Cambridge Museum, which would lead one to a false conclusion. Nathorst * has already instanced similar specimens from Japan. I am therefore not disposed to attach much importance to this character of the genus as an aid to its identification. As we shall see (p. 116) in the single instance in which the leaflets of the species of *Zamites*, described here, have been found attached to the rachis, the insertion appears to be lateral, although in reality it may have been dorsal.

On the whole, I consider Schimper's definition the most satisfactory as yet available. The fossils described here will be found to agree with it in detail.

The Species ZAMITES GRANDIS, *nom. nov.* (Pl. 17; Pl. 18. fig. 2; Pl. 19. figs. 1–3.)

1844. *Yuccites vogesiacus,* Schimper & Mougeot, Monogr. Plant. foss. Vosges, p. 42, pl. 21. figs. 1, 2.
1844. *Yuccites dubius,* Schimper & Mougeot, *ibid.* foot of pl. 21.
1865. *Pterophyllum giganteum,* Schenk, Flora Schwarz. Schiefer, Raibl, p. 18, pl. 2. fig. 2.
1870. *Yuccites vogesiacus,* Schimper, Traité, vol. ii. p. 427.
1870. *Macropterygium schenkii,* Schimper, *ibid.* p. 133.
1907. *Zamites vogesiacus,* Arber, in Wills, Geol. Mag. dec. 5, vol. iv. p. 32.

Localities.—The Bunter of the Vosges (Alsace), Germany; the Keuper of Bromsgrove (Worcestershire), England; the Lower Keuper of Raibl (Carinthia), Austria; and ? the Lower Keuper of Apolda (East Thuringia), Germany.

Diagnosis.—Frond pinnate. Pinnæ very large, most frequently detached, varying greatly in size, from 30–50 cm. in length and from 3–6·5 cm. or more at their greatest width, entire, lanceolate or somewhat linear-lanceolate; apex elongate, acuminate; base somewhat abruptly contracted, with a fairly well-marked callosity at the point of attachment, basal margin crescentic. Nerves strictly parallel, occasionally dichotomising, stout, close, numerous, not spreading nor diverging. Surface much puckered and pitted.

* Nathorst (1890), p. 46.

Description of the Specimens.

The lanceolate or linear-lanceolate pinna * figured on Pl. 17. fig. 1, reduced to half natural size, is almost complete, with the exception of a small portion of the apex, which is missing. It measures about 37·5 cm. in length, and 4·6 cm. across at its greatest width. At the base it narrows somewhat sharply to a breadth of 1·4 cm. The basal callosity is not very evident in the photograph. The general parallel course of the nervation can be made out fairly clearly in this specimen. The surface of the leaflet shows numerous puckerings, which are also evident on nearly all the examples of this frond.

An even larger pinna † is figured on Pl. 17. fig. 3, also reduced to half natural size. It is an almost complete leaflet, except that a small part of the base and a portion of the apex are wanting. It is the largest example obtained from Worcestershire. The complete pinna must have been nearly 50 cm. in length, and was about 6·7 cm. across at its greatest breadth. At the base it contracts to between 2–3 cm. in width. The lanceolate form of the leaflet is striking and the nervation is fairly clear.

Another specimen ‡, a basal portion of a pinna, is figured on Pl. 17. fig. 2, natural size, to show the nervation. It measures 23 cm. in length, and 5·5 cm. at its broadest part. The nerves appear to be stout and close, and are strictly parallel, with occasional dichotomy.

On the same specimen there is also another fragment of a pinna, 21 cm. long, in which the apex is quite complete. This is figured on Pl. 18. fig. 2 (natural size). The acuminate and elongate extremity of the pinna, ending quite acutely, is here well seen. The leaflet appears to be somewhat falcate in its upper portion, though this feature is not very evident in the present specimen owing to a slight distortion, due to the unevenness of the surface of the marl on which it rests. The curious puckered appearance of the surface of the leaflet, of frequent occurrence, is specially noticeable in this example.

The photograph on Pl. 19. fig. 1 shows the apical portion of an almost complete leaflet (natural size) §, which had become bent upon itself before incrustation took place. The entire pinna in the living state probably exceeded 40 cm. in length, with a maximum breadth of 5·5 cm. The apex is wanting. An excellent example ‖ of an apical portion in which the actual tip of the leaflet is also missing is seen on Pl. 19. fig. 3 (natural size). It measures 14 cm. in length, and 5·5 cm. at greatest breadth. The falcate form of the apex is well shown.

The photograph on Pl. 19. fig. 2 (natural size) shows a basal fragment ¶, about 8 cm. in length, of a rather small leaflet. The thickening or callosity at the base is clearly seen. Another basal portion ** (Pl. 17. fig. 4), belonging to a still more slender pinna, shows the callosity, and also the contracted nature of the base of the leaflet, though the nervation is only very faintly marked.

* No. 24. British Triassic Plant Coll., Sedgwick Museum.
† No. 25. Ditto. ‡ No. 26. Ditto. § No. 22. Ditto.
‖ No. 27. Ditto. ¶ No. 28. Ditto. ** No. 30. Ditto.

The whole of the above specimens were collected by Mr. L. J. Wills, B.A., from Mr. Griffin's North Quarry in the Keuper Marls at Rock Hill (Hill Top), one mile south-east of Bromsgrove, Worcestershire *, and were presented by him to the Sedgwick Museum, Cambridge.

Affinities of the Species.

The leaflets from the British Keuper Rocks, described above, are identical with certain fossils from the Bunter of the Vosges, figured by Schimper and Mougeot † in 1844, under the name *Yuccites vogesiacus* ‡. The type specimens are not to be found in the Strasburg University Museum, where I have sought for them in vain. There are, however, in that collection, a large number of other specimens, which there is every reason to believe are identical with the figured specimens, and also with the English examples discussed here. At the same time Schimper and Mougeot's figures do not give at all an accurate idea of these fossils, although there is very little doubt what they are intended to represent, when one compares the Strasburg material with them.

For reasons which will be discussed here, I have no hesitation in referring both the specimens from the Vosges, and the newly discovered, British representatives to the frond-genus *Zamites*. The specific name which would naturally be adopted for these fossils is *Zamites vosgesiacus* (Schimper & Mougeot), but, by an unfortunate circumstance, this term is not available. For the same authors, in the same memoir, have also figured and described a totally different plant § under that name, the type of which is preserved at Strasburg, where I have examined it. Unfortunately it proves to be a very obscure impression of a Cycad-like frond, in sandstone, the genus of which is quite indeterminable. Despite Schimper and Mougeot's figures, the nervation is not visible, and the outlines of the pinnules are but feebly marked. The specimen, however, remains the type of *Z. vogesiacus*, Schimp. & Moug., and a new specific name must be adopted for the *Yuccites vogesiacus* of those authors, on its transference to the genus *Zamites* ‖. I therefore propose the name *Z. grandis*, nom. nov., in allusion to the large size of the pinnæ of these fronds.

We may now turn to a discussion on the generic affinities of this and of other closely similar fossils; a subject of much confusion in the past, and the cause of considerable difficulty at the present.

Schimper and Mougeot ¶ regarded these fossils as simple leaves, with a parallel nervation, referable to the Monocotyledons, and therefore included them within the genus *Yuccites*, as members of the Liliaceæ. Zigno ** has also figured a Jurassic

* Wills (1907), p. 29.

† Schimper & Mougeot (1844), p. 42, pl. 21.

‡ The stem figured by Schimper and Mougeot (1844), p. 43, pl. 29. fig. 4, and attributed to this plant, belongs, in all probability, to the Conifer *Voltzia*: see Blanckenhorn (1886), p. 135, and Schütze (1901), p. 245.

§ Schimper & Mougeot (1844), p. 34, pl. 18. fig. 1.

‖ When I compiled the list of plant-remains given in Mr. Wills's paper (1907), p. 32, I unfortunately overlooked the fact that Schimper and Mougeot specific name could not be applied to these specimens.

¶ Schimper & Mougeot (1844), p. 42; Schimper (1869), vol. ii. p. 426.

** Zigno (1873), p. 7, pl. 26. figs. 1–4.

plant from Italy, which he refers to this same genus, under the name *Yuccites Schimperianus*, Zigno, which is almost certainly *generically* identical with the Triassic fossils discussed here. Again the *Yuccites burgundiacus* of Saporta *, from the Bathonian of France, is of like affinity, though the *Y. angustior* of the same author †, from the Bunter of the Vosges, is, judging by its reticulate nervation, quite distinct generically. Saporta ‡ referred the genus *Yuccites* to his group of Proangiosperms.

The plant figured by Compter §, from the Lower Keuper of East Thüringia, under the name *Cordaites keuperianus*, sp. n., agrees very closely in shape with the specimens described here. It is possible that it may even be specifically identical with the British fossils, though it appears to be rather smaller, and, not having seen the specimen, I have hesitated to unite them.

Velenovský ‖ has figured some leaves, which he termed *Krannera mirabilis*, from the Cretaceous of Bohemia, which bear a very close resemblance to the specimens under discussion here. That author, however, suspected that these leaves were attached directly to stems of a curious, cone-like form, with which they were associated. The matter thus remains in doubt, with a distinct possibility that the leaves assigned to *Krannera* may eventually prove to be of a similar nature to *Zamites grandis*.

My interpretation of these fossils is an entirely different one. I believe them to be simply the detached pinnæ of a large frond of the Zamitean type, with long leaflets. It is true that in many of the typical members of the genus *Zamites*, such as *Z.* (*Williamsonia*) *gigas* (Lindl. & Hutt.) from the Lower Oolite, *Z. Feneonis*, Brongn., from the Kimmeridgian, or *Z. buchianus* (Ett.) from the Wealden, the pinnæ are only of moderate length, and are almost invariably still attached to the rachis, and thus the frond, even if fragmentary, is complete in this respect. But in the case of a frond with very long and large pinnæ, the latter would naturally be more liable to have become detached from the rachis during the process of preservation.

The form and nervation of these detached pinnæ agree exactly with those of the better known species mentioned above, in which the leaflets are by comparison short. They show the same sudden contraction in width, near the point of insertion, and a basal callosity; in fact all the characters included in Schimper's definition, already discussed.

It is true, however, that, neither in the case of the English specimens, nor the examples from the Vosges, has a frond been found with the pinnules attached to the rachis. But continuity between these organs is certainly to be seen in the case of a frond from the Keuper of Raibl, in Austria, named by Schenk ¶ *Pterophyllum giganteum*. Schenk's type is preserved in the Geological Museum of the University of Würzburg, where I have had the pleasure of seeing it. Schenk, in his description, pointed out the

* Saporta (1891), p. 79, pl. 236. figs. 1, 1 *a*.

† Saporta (1891), p. 74, pl. 234. fig. 1.

‡ Saporta (1891), p. 69.

§ Compter (1894), p. 225, pl. 4. fig. 9.

‖ Velenovský (1885), p. 1, pl. 1. figs. 1, 4, 5, 6, 7.

¶ Schenk (1865), pp. 18, 19, pl. 2. fig. 2.

obvious similarity of this frond to that of the recent Cycads, especially *Ceratozamia*. He also compared it with *Pterophyllum Bronni*, Schenk (see p. 120), and referred it to the same genus. The special interest of this specimen lies in the fact that the pinnæ are attached, apparently laterally, to a broad rachis. Since the pinnæ are all in continuity, it is impossible to say whether a callosity occurs at the base of each. The general shape of the leaflets, bearing in mind, as Schenk has pointed out, that the apical portions are wanting, as well as the characters of the nervation, lead me to regard it as identical with, or scarcely distinguishable from, *Zamites grandis*.

Although in Schenk's specimen the leaflets are apparently attached laterally, it by no means follows that such was really the case in the living state. I have already commented (p. 113) on the difficulties of ascertaining the exact manner of attachment in many specimens of Zamitean fronds. I see no reason to regard this leaf as being other than a pinnate frond, though Schimper * placed it in a new genus *Macropterygium*, as a new species *M. Schenkii*.

If my view of the nature and attribution of Schenk's fossil is correct, then the case in favour of the interpretation, here adopted, of the leaflets of *Zamites grandis*, from England and the Vosges, is greatly strengthened.

Further evidence may be found in a common fossil from the Stonesfield Slate of England, *Zamites megaphyllus* (Phillips), which has recently been redescribed by Prof. Seward †. This is a leaflet very closely allied to *Zamites grandis*, but apparently specifically distinct, for the apex is more elongately acuminate and the pinnæ are more nearly linear in form. The pinnæ, as a rule, also occur detached, and may be more than 30 cm. long. The Cycadean affinity of the frond was, however, early recognised in this case, for one of Phillips's ‡ type specimens (recently refigured by Seward §) shows the leaflets apparently in continuity with the rachis; though here again the precise manner of attachment is not very evident. I am in agreement with Prof. Seward who says "on the whole I incline to the opinion that the numerous Monocotyledon-like leaves from Stonesfield are the pinnæ of a Cycadean frond" ‖.

Solms-Laubach ¶ has also called attention to the fact that, in some fronds of *Zamites*, the pinnules frequently become isolated from the rachis, and in this condition may have been liable to misidentification.

Lastly, in this connection, it may be pointed out that Cycad-like fronds with very long pinnæ have been referred to other genera, in which the leaflets are, in the majority of cases, only of moderate length. The Rhætic fossil *Podozamites distans*, Presl, var. *longifolia*, Schenk **, is a good example. A detached leaflet of such a frond would be just as liable to misidentification as one of the pinnæ of *Zamites grandis*.

We may therefore conclude, viewing the whole of this evidence, that there are strong reasons to be adduced in support of the interpretation of the Keuper fossils maintained here.

* Schimper (1869), vol. ii. p. 132.
† Seward (1904), p. 110, pl. 10. figs. 4–5, pl. 12. figs. 1, 3–5, and text-fig. 11.
‡ Phillips (1871), p. 169, diag. 30. fig. 6.
§ Seward (1904), p. 114, text-fig. 11.
‖ Seward (1904), p. 111.
¶ Solms-Laubach (1891), p. 88.
** Schenk (1867), p. 162, pl. 37. fig. 1.

There are, however, several other genera with which these leaflets, and especially imperfect, detached fragments of the pinnæ, are liable to be confused, and these may be briefly noticed.

Nœggerathia, Sternberg.—This genus is now restricted to certain leaves, known only from the Westphalian rocks of Bohemia, of which *N. foliosa*, Sternb., is the typical species. Its affinities are wholly uncertain. The only specimens of *Zamites grandis*, which might be confounded with it, are short basal fragments of the leaflets, which are easily distinguished by the callosity at the point of attachment, and by the sudden contraction in width at the proximal extremity.

Cordaites, Unger (including *Rhiptozamites*, Schmalhausen).—Some imperfect fragments of the leaflets of *Zamites grandis* recall rather vividly certain leaves of *Cordaites*, but when complete pinnæ are available they are easily recognised by the basal characters, and also by the fact that they are the leaflets of a pinnate frond, and not leaves spirally arranged on a shoot.

Nœggerathiopsis, Feistmantel.—In the case of this imperfectly-known member of the Glossopteris flora, probably closely allied to, if not identical with, *Cordaites*, where the manner of attachment of the leaves is as yet undetermined, the detached pinnæ of *Zamites grandis* are with difficulty distinguished, and then chiefly by their basal characters. It is possible that the fossils from the Rhætic rocks of Tonkin, referred to *N. Hislopi* by Zeiller *, may be fragments of leaflets of a Cycad-like frond with long pinnæ, but the matter must remain doubtful for the present. One of Zeiller's figures, however, shows a distinct basal callosity.

Podozamites, Bronn.—The species of this genus with long leaflets are easily distinguishable from *Z. grandis*, by the fact that the pinnæ are much more narrowly contracted at the base, and the veins less numerous and less crowded. The manner of arrangement of the leaflets on the axis or rachis is also a distinctive feature.

It has been seen that, on the interpretation of the Triassic fossils discussed here, there are good reasons for regarding as portions of Zamitean fronds with very long pinnæ several other, previously described examples (see pp. 115–116) from rocks of various ages, hitherto assigned to such genera as *Yuccites* and *Cordaites*, some of which have been attributed with confidence to the class Monocotyledons. The list could be considerably extended. The fossils figured by Heer, and more recently by Leuthardt †, from the Keuper of Neue Welt, near Basle (Switzerland), under the name *Bambusium Imhoffi*, Heer, of which I have seen an example in the Basle Museum, are almost certainly pinnæ of a Zamitean frond, and may even be identical with, or closely related to, *Zamites grandis*. This again, in the opinion of Dr. Leuthardt in his recent memoir, is an example of a Triassic Monocotyledon.

It is possible that some of the leaves now assigned to the genus *Phœnicopsis*, Heer, more especially *P. elongatus* (Morris) ‡ from the Rhætic of New South Wales and

* Zeiller (1902), p. 149, pl. 40. figs. 1–6, ? 7–8.

† Leuthardt (1903), pt. 1, p. 6, pl. 1. figs. 1–3.

‡ Seward (1903), p. 67, pl. 9. figs. 1, 9, 10.

S. Africa, may have been the long detached pinnæ of fronds similar in type to, but distinct from, *Zamites grandis*, though the evidence in this case is not so strong.

In collections of the Rhætic flora of Theta, near Bayreuth, in Bavaria, one sometimes notices such a leaf as that figured on Pl. 18. fig. 3 (¾ nat. size). They are of considerable length, 19 cm. in the figured example *, and of linear form, with a fine, rather faint, parallel nervation. For some time past I had been puzzled as to the generic identity of this fossil, which apparently was not described by Schenk † in his Monograph of this flora, nor by any subsequent author. When, however, the English material of *Zamites grandis* came into my hands, I realised that, in all probability, this specimen was another example of a detached leaflet of a species of *Zamites* with very long, narrow pinnæ. It is interesting to find that the surface of the leaflet of this Rhætic fossil shows numerous small pittings or puckerings, recalling those which occur on the specimens from the English Keuper.

It may be also pointed out that several species of Cycad-like fronds, with very long pinnæ, have been already referred to the genus *Zamites*. In addition to *Z. megaphyllus* (Phillips), the following are cases in point:—*Z. africana* (Tate) ‡, *Z. Milleri*, Zigno §, and possibly *Z. Renevieri*, Heer ‖. The frond recently figured by Ward ¶ as *Zamia Washingtoniana* is probably another example.

PTEROPHYLLUM BRONNI, *Schenk*.

The genus *Pterophyllum*, like the genus *Zamites*, is known from the Palæozoic rocks, but, unlike the latter, it is already known to be a very abundant and typical type of frond in the Keuper rocks of Europe, and also in the Rhætic. The study of the Zamitean fronds from the English Keuper naturally led to a comparison with the Austrian fossil, first described by Bronn as *Næggerathia vogesiaca*. The loan from the Munich Museum of the excellent example figured here, for which I am greatly indebted to Prof. Rothpletz, has extended our knowledge of this very interesting fossil, and has given an opportunity for the publication of more accurate figures than those of Bronn, which appeared nearly fifty years ago.

The Genus PTEROPHYLLUM, *Brongniart*, 1825.

(Ann. Sci. Nat. sér. i. vol. iv. p. 211.)

This generic name was originally proposed by Brongniart for two Swedish fossils, which are now transferred to another genus. In 1828, however, the same author ** gave the following diagnosis of the genus, and included under it such typical species as

* No. 294, Foreign Plant Coll., Sedgwick Museum. A specimen in the British Museum (Nat. Hist.), No. 15,049, is 25 cm. in length.

† Schenk (1867).

‡ Seward (1903), p. 25, pl. 5. fig. 5.

§ Zigno (1873), vol. ii. p. 40, pl. 30. fig. 6; Miller (1872), p. 432, text-fig. 136.

‖ Heer (1865), p. 144, text-fig. 95; Saporta (1875), vol. ii. p. 112, pl. 93. fig. 2.

¶ Ward (1905), p. 503, pl. 111. fig. 1.

** Brongniart (1828), p. 95.

P. Jægeri and *P. longifolium* from the Keuper rocks:—"Feuilles pinnées, à pinnules d'une largeur à peu près égale, s'insérant sur le pétiole par toute la largeur de leur base, tronquées au sommet; nervures fines, égales, simples, peu marquées, toutes parallèles."

Schimper * restricted the genus to leaves with strictly linear leaflets, an emendation which has since been generally accepted. The recent definition of *Pterophyllum* given by Prof. Zeiller † may be quoted as an accurate analysis of the chief characters of the fossils usually included under this name:—

"Frondes simplement pinnées; folioles linéaires, plus ou moins longues par rapport à leur largeur, tantôt tronquées, tantôt arrondies, plus rarement effilées en pointe à leur sommet, attachées au rachis par toute leur largeur, quelquefois même non peu élargies à leur base; parcourues par des nervures simples ou dichotomes, parallèles entre elles."

It will be seen that the species described here as *Pterophyllum Bronni*, Schenk, does not agree in certain important respects with this definition of the genus. A discussion of this question may, however, be reserved until a description of the specimen has been given.

The Species PTEROPHYLLUM BRONNI, *Schenk*, 1865.
(Plate **18.** fig. 1; Plate **19.** fig. 4.)

1858. *Næggerathia vogesiaca* (*non* Schimp. et Moug.), Bronn, Beitr. trias. Fauna & Flora Raibl, p. 129, pl. 6. figs. 1–4.

1865. *Pterophyllum Bronnii*, Schenk, Flora Schwarz. Schiefer, Raibl, p. 18.

1870. *Macropterygium Bronnii*, Schimper, Traité Pal. Végét. vol. ii. p. 132.

Locality.—Keuper of Raibl, Carinthia, Austria.

Diagnosis.—Frond large, pinnate. Rachis stout, from 1–1·5 cm. in breadth, faintly striated longitudinally. Pinnæ large, entire, spreading; varying slightly in size and shape, on an average 15 cm. or more in length, and 5 cm. or more across at their greatest width, a little below the apex; cuneate or more or less oblanceolate. Margin entire; apex truncated, usually somewhat unsymmetrical; lateral angles rounded. Base not markedly contracted. Nerves fine, very numerous, close, parallel, straight, terminating at the broad apex, and not bending outwards towards the margin.

Description of the Specimen.

The fine specimen in the Munich Museum (figured on Pl. **18.** fig. 1, reduced to two-thirds natural size) shows a small fragment of the rachis and portions of five pinnæ, all probably belonging to the same frond. The uppermost leaflet is almost complete (Pl. 19. fig. 4). It measures 16·2 cm. in length, and 5·3 cm. across at its greatest breadth. The apex appears to be slightly emarginate; but this is very possibly due to some accident in the preservation, for it does not appear to be the case in the other pinnæ, in all of which the distal extremities are quite intact. At the base, the pinna is imperfect and obscure, and it cannot be ascertained with certainty whether it is still

* Schimper (1869), vol. ii. p. 133. † Zeiller (1903), p. 174.

attached to the fragment of the rachis seen below (*cf.* Pl. 19. fig. 4). The nervation is not very distinct neither in this nor any of the other leaflets, though the course of the veins is quite clear. The dichotomy of the veins at the base, and occasionally throughout the lamina, cannot be clearly made out, though there is good reason to suppose that it occurs. There is a possibility that this leaflet may have been the terminal pinna of the frond, but this again is a point which cannot be satisfactorily decided. In the photograph on Plate 19. fig. 4 it is shown natural size.

The next highest pinna on the right-hand side is shorter, the length being 4·4 cm., and its greatest breadth about 4 cm. At the base it appears to be distinctly narrowed near the point of attachment, but its width here may well have been somewhat greater in the living state. It is, in all probability, still attached to the rachis (*cf.* Pl. 19. fig. 4).

The next lowest leaflet is almost certainly attached for a distance of about 1·2 cm., though a part of the base is missing (*cf.* Pl. 19. fig. 4). It is 13·8 cm. long and 5·4 cm. across at its broadest part. There is no trace of any callosity at the base in either this instance or that of the pinna next above. The unsymmetrical nature of the apex is clearly seen.

The two lower pinnæ, each about 5 cm. broad at their widest part, are imperfect, but show the apical characters very well.

The photograph on Plate 19. fig. 4 shows a portion of the same specimen slightly below natural size. In addition to the terminal pinna, the rachis (*r.*), with two pinnæ still attached, is clearly seen.

Affinities of the Species.

The generic attribution of this fossil raises a difficult question, and one on which there has already been some difference of opinion. Bronn *, in his original description published in 1858, regarded it as the same plant as Schimper and Mougeot's *Yuccites vogesiacus*, here described under the name *Zamites grandis*, nom. nov., though he admitted that at first sight it appears to be very different. There can be no question that the Raibl plant is not specifically identical with the specimens from the Bunter of the Vosges and the Keuper of England, as all authorities are agreed, but the problem remains as to whether it is *generically* distinct, and, if so, the genus in which it should be placed.

Attention may here be called to one or two points in connection with Bronn's figures. In the first place, as Schenk † has already pointed out, the leaflets are quite simple and entire, and not lobed as Bronn's specimens indicated; an appearance no doubt due to bad preservation. Although one of the examples figured by that author ‡ shows a rachis with several, rather distant, leaflets attached, Bronn inclined to the opinion that, on the whole, it represented a shoot, bearing leaves arranged as in *Næggerathia.* Schimper § compared it with *Podozamites*, and instituted a new genus *Macropterygium* for its reception.

* Bronn (1858), p. 129.

† Schenk (1865), p. 18.

‡ Bronn (1858), pl. 6. fig. 1.

§ Schimper (1869), vol. ii. p. 132.

Though the matter can hardly be said to be finally proved at present, there appears to be a very strong probability that the leaf of this species was really a pinnate frond, and that, like *Zamites grandis*, the large leaflets frequently became detached from the rachis, as in the case of several of Bronn's figured examples. The arrangement of the leaflets in the specimen figured here (Pl. 18. fig. 1), although the fossil is admittedly imperfect, in conjunction with the frond described by Bronn, in which the pinnæ are still attached to the rachis, will hardly permit of any other conclusion, though the question cannot be finally settled until more complete specimens have been obtained.

In this view of the Raibl specimen, I am in agreement with Schenk *, who in 1865 decided that its affinities lay in the direction of the *Cycadophyta*, and corrected Bronn's specific determination. Schenk further concluded provisionally that the fossil most nearly approaches the genus *Pterophyllum*, and adopted the new name *P. Bronni*, which is that provisionally made use of here. There are only two other fossils with which I am acquainted which at all resemble this plant. One of these is the *Sphenozamites Rogersianus* of Fontaine †, from the Triassic rocks of the Richmond coalfield in Virginia, U.S.A. Fontaine's figures do not, however, agree very well with the Austrian specimen, though Stur ‡ has gone so far as to say that both are specifically identical. Yet as regards generic affinity, the two plants are obviously closely related. In the size and shape of the leaflets, the American specimens show a striking agreement with Bronn's species, especially as regards the apex. The basal characters are, however, different, judging by Fontaine's figures, which show pinnæ attached only by a small portion of the base, the upper and lower basal angles of which are rounded. In the specimen described here the pinnæ are strictly wedge-shaped, and apparently attached by their entire base. The nervation also differs. In the Austrian specimen, no trace of transverse striæ between the nerves can be detected, and the veins pursue a more parallel course direct to the apex, and do not radiate as in the figure of the American plant. This frond, however, as a whole, supports the conclusion as to the pinnate nature of the leaf described here.

The other species, *Sphenozamites tener* of Compter §, from the Keuper of Thüringia, is considerably smaller than the Raibl specimen, and does not appear to be very closely related. The first specimens figured were fragmentary, and consisted for the most part of detached pinnæ. In these the shape is rhomboidal rather than cuneate, and the nervation appears to approximate more closely to that of the genus *Sphenozamites*. Compter also figures the cells of the epidermis of the leaflets, which he points out are of the Cycadean type. A further specimen, figured by the same author in 1894, has several fragments of pinnæ united to the rachis. On the whole it shows obvious points of agreement with the figures of *S. Rogersianus* given by Fontaine, though it is no doubt a smaller plant specifically distinct.

* Schenk (1865), p. 18.

† Fontaine (1883), p. 80, pl. 43. fig. 1, pl. 44. figs. 1 & 2, pl. 45. figs. 1 & 2.

‡ Stur (1888), p. 210.

§ Compter (1883), p. 12, pl. 1, and text-figs. 10–17, and Compter (1894), p. 222, pl. 4. fig. 3.

The question as to the genus, to which the frond described here should be referred, is a difficult one, and the following genera may now be considered in this connection.

Sphenozamites.—It does not appear to me to be possible to attribute the Raibl fossil to this genus, as at present defined. The name *Sphenozamites* was proposed by Brongniart, in 1849, to include fronds of the *Otozamites*-type, which were not auriculate at the base, and possessed a radiating nervation. In the specimens referred to *Sphenozamites* and figured by Zigno *, Renault †, Seward ‡, and others, the spreading nature of the nervation is clearly seen, and the shape of the pinnules more closely approximates to the rhomboidal than to the cuneate form. The margin in some species is also toothed.

It might, perhaps, be possible to extend the diagnosis of this genus so as to include the Raibl species, but at the present time such an attempt would hardly seem advisable.

Zamites.—The specimen discussed here appears to be quite distinct from the fossils attributed to this frond-genus, both as regards the shape of the pinnæ, and in respect to the nervation. As compared with *Zamites grandis*, the nerves are sometimes finer and closer, and there is no evidence of a callosity at the base of the leaflet. Zeiller § has, however, recently described a frond from the Rhætic of Tonkin under the name *Zamites truncatus*, Zeiller, in which the shape and nervation of the leaflets offer some points of comparison with the present specimen, but the pinnæ are much smaller, and the agreement is not a close one.

Pterophyllum.—It is admitted that this plant differs from typical members of this genus in a marked degree, especially as regards the size and shape of the pinnæ. Yet it appears to me to be more closely allied to *Pterophyllum* than to any other frond genus with which I am acquainted. In some of the typical species of *Pterophyllum* from the Triassic rocks, especially *P. longifolium*, Brongn. ‖, the leaflets are sometimes contracted at the base and broadest at the apex, thus approximating in some slight degree towards the cuneate form, though they are on a much smaller scale than in *P. Bronni.* If we were to imagine such a frond magnified several times and the wedge-like shape of the pinnæ further accentuated, we should arrive at a leaf which would correspond fairly closely with the latter species both in form and nervation.

On the whole we may conclude that the Raibl fossil agrees with the diagnoses of this genus given by Brongniart, Zeiller, and others, with the chief exception that the pinnæ are broadly wedge-shaped in form and not linear. It would thus seem preferable to adopt Schenk's provisional reference of this plant to the genus *Pterophyllum*, than to make use of Schimper's term *Macropterygium.*

It remains to be pointed out that detached pinnæ of this frond, especially when fragmentary, are liable to be mistaken for the leaves of *Cordaites* and other genera in which the nervation is closely similar, but which are simple leaves, spirally arranged

* Zigno (1873), vol. ii. p. 105, pls. 39 & 40.

† Renault (1893), p. 327, pl. 81. fig. 1.

‡ Seward (1904), p. 119, pl. 11. fig. 4, and text-fig. 12 on p. 120.

§ Zeiller (1902), p. 166, pl. 43. figs. 3–6.

‖ *Cf.* Leuthardt (1903), pt. i. p. 16, pls. 7–10.

on branches. They also strongly resemble detached leaflets of the Upper Carboniferous genus *Nœggerathia* *, whose affinities remain wholly doubtful.

General Conclusions.

The two fossils described here belong to a flora as yet comparatively little known. Both are derived from approximately the same horizon, the Keuper; the one from England, the other from Carinthia. Among the known fossil plants of Cycadophytean affinity they may be considered as exceptional instances of megaphylly. Yet as regards mere size they are in no way remarkable when compared with the fronds of many species of living Cycads.

The specimens discussed here under the name *Zamites grandis*, nom. nov., illustrate the difficulties which arise as a corollary of the fragmentary preservation of such large fronds. In nearly every case the pinnæ have become detached, and usually the leaflets themselves are incomplete. Such impressions are often extremely difficult to determine. It has been shown here that the long Monocotyledon-like leaves, often nearly 50 cm. in length, which have recently been discovered in the Keuper rocks of Bromsgrove, are in reality the large detached pinnæ of a Cycadophytean frond belonging to the form-genus *Zamites*. This conclusion has thrown light on a considerable number of similar Mesozoic fossils, previously described under the names *Yuccites*, *Cordaites*, *Bambusium*, &c., and regarded as evidence of the existence of Monocotyledons, Proangiospermeæ, Cordaitales, or other groups in the earlier Mesozoic rocks.

The fronds of *Zamites grandis* are practically the first well-preserved plant-remains which have ever been described from the British Trias, excluding the Rhætic. Only a few obscure impressions, chiefly of cones and Equisetaceous stems, have hitherto been recorded, and even these have proved to be of rare occurrence †. They also fill a gap in our knowledge of the vertical distribution of this genus, for *Zamites*, although known from the Palæozoic rocks, has not hitherto been recognised beyond doubt from Mesozoic sediments of earlier age than the Rhætic. Incidentally the recognition of this species from England tends to emphasise the close affinity of the fossil plants from the various Triassic deposits of Europe, for it is now known from the Bunter of the Vosges, the Lower Keuper of Carinthia, and possibly also from the same horizon in Thüringia.

The other species described here, *Pterophyllum Bronni*, Schenk, is a very rare type of frond, known only from the earlier Triassic rocks of the Continent, and possibly also from beds of the same age in the United States. Apart from its large size, it is especially interesting on account of the difficulty of including it within the limits of any of the recognised frond-genera of Cycadophyta. It is by no means a typical example of a *Pterophyllum*, though it appears to be on the whole more closely allied to that genus than to any other.

* See Solms-Laubach (1891), pp. 141 and 151.

† In addition to the specimens described here, Mr. Wills has obtained several other well-preserved plant-remains from the same locality in the Keuper of Bromsgrove, which he has also presented to the Sedgwick Museum, Cambridge, and is describing.

In some respects it may be regarded as combining characters common to several Mesozoic Cycad-like fronds, for one can easily see how smaller leaves, such as those of *Sphenozamites*, or of other species of *Pterophyllum*, or even some Zamitean fronds, could be derived from it. On the other hand, if the *individual leaflets* of the pinnate frond are alone considered, they show a very remarkable similarity to the *leaves* of the Palæozoic genera *Cordaites* and *Nœggerathiopsis*.

It is, perhaps, hardly necessary to add that it is impossible to correlate either of these fronds with those of living genera of Cycads. Wieland has recently pointed out that great variations in the size and form of the leaves are found within a single genus of these plants. He says "the pinnules of the Zamias present many gradations, from linear forms quite as narrow and long as pine needles to elliptical or somewhat spatulate, thick, and fleshy forms like those of *Z. furfuracea*, which strongly recall the blades of certain species of Cordaiteæ" *. Further, we know that several species of the Mesozoic *Zamites* have proved to be the foliage, not of Cycads, but of a very distinct race, the Bennettiteæ.

Bibliography.

Arber, E. A. N. (1905).—Catalogue of the Fossil Plants of the *Glossopteris* Flora, being a Monograph of the Permo-Carboniferous Flora of India and the Southern Hemisphere. Brit. Mus. Catal. London, 1905.

Blanckenhorn, M. (1906).—Die fossile Flora des Buntsandsteins und des Muschelkalks der Umgegend von Commern. Palæontogr. Bd. xxxii. Lief. 4, 1886.

Brongniart, A. (1828).—Prodrome d'une Histoire des Végétaux fossiles. Paris, 1828.

—— (1849).—Tableau des Genres de Végétaux fossiles. Dictionnaire universel d'Histoire naturelle, vol. xiii. p. 52. Paris, 1849.

Bronn, H. G. (1858).—Beiträge zur triasischen Fauna und Flora der bituminösen Schiefer von Raibl, &c. Jahrb. für Mineral. &c. für 1858, p. 129.

Compter, G. (1883).—Zur fossilen Flora der Lettenkohle Thuringens. Zeitschr. Naturwiss. Halle. vol. lvi. (ser. 4, vol. ii.) p. 1, 1883.

—— (1894).—Die fossile Flora des untern Keupers von Ostthüringen. Zeitschr. Naturwiss. Leipzig. vol. lxvii. (ser. 5, vol. v.) p. 205, 1894.

Fontaine, W. M. (1883).—Contributions to the Knowledge of the Older Mesozoic Flora of Virginia. Monograph vi. U.S. Geol. Surv. Washington, 1883.

Goeppert, H. R. (1866).—Beiträge zur Kenntniss fossiler Cycadeen. Neu. Jahrb. Miner. für 1866, p. 129.

Heer, O. (1865).—Die Urwelt der Schweiz. Zürich, 1865.

Leuthardt, F. (1903).—Die Keuperflora von Neuewelt bei Basel. Theil. i. & ii. 1903-4. Abhandl. Schweiz. paläont. Gesell. vol. xxx. 1903, vol. xxxi. 1904.

Miller, Hugh (1872).—The Testimony of the Rocks. 40th Thousand, 1872.

Nathorst, A. G. (1890). Beiträge zur mesozoischen Flora Japans. Denkschr. k. Akad. Wissen. Wien, vol. lvii. p. 43, 1890.

Phillips, J. (1871).—The Geology of Oxford and the Valley of the Thames. Oxford, 1871.

* Wieland (1906), p. 191.

Renault, B. (1881[1]).—Sur les *Sphenozamites.* Compt. Rend. Acad. Sci. vol. xciii. p. 1165, 1881.

—— (1882[2]).—Note sur les *Sphenozamites.* Arch. bot. Nord France = Rev. Bot. Mensuel. vol. i. p. 180, 1881.

—— (1893).—Flore fossile du Bassin houiller et permien d'Autun et d'Épinac: Part II. Texte, 1896; Atlas, 1893. Étud. Gîtes Minér. France, 1893–96.

—— et Zeiller, R. (1886).—Sur quelques Cycadées houillères. Compt. Rend. Acad. Sci. vol. cii. p. 325, 1886.

Saporta, Marquis G. de (1875).—Plantes Jurassiques: vol. ii. Cycadées. Paléont. franç. sér. 2, Végétaux, Paris, 1875.

—— (1891).—Plantes Jurassiques: vol. iv. Types proangiospermiques etc. Paléont. franç. sér. 2, Végétaux, Paris, 1891.

Schenk, A. (1865).—Ueber die Flora der Schwarzen Schiefer von Raibl. Würzburg. Naturw. Zeitschr. vol. vi. p. 10, 1865.

—— (1867).—Die fossile Flora der Grenzschichten des Keupers und Lias Frankens. Text and atlas. Wiesbaden, 1867.

Schimper, W. P. (1869).—Traité de Paléontologie Végétale, vols. 1–3. Paris, 1869–74.

Schimper et Mougeot, A. (1844).—Monographie des Plantes fossiles du Grès bigarré de la chaîne des Vosges. Leipzig, 1844.

Schütze, E. (1901).—Beiträge zur Kenntniss der triasischen Koniferengattungen: *Pagiophyllum*, *Voltzia*, und *Widdringtonites.* Jahresh. 57. Ver. vaterl. Naturk. Württemberg, p. 240, 1901.

Seward, A. C. (1895).—The Wealden Flora: part ii. Gymnospermæ. Cat. Mesoz. Plants Brit. Mus. London, 1895.

—— (1903).—Fossil Floras of Cape Colony. Annals S. African Museum, vol. iv. pt. 1, 1903.

—— (1904).—The Jurassic Flora: ii. Liassic and Oolitic Floras of England. Cat. Mesoz. Plants Brit. Mus. London, 1904.

Solms-Laubach, H. Graf zu (1891).—Fossil Botany (Engl. Edit.). Oxford, 1891.

Stur, D. (1888).—Die Lunzer (Lettenkohlen) Flora in den "Older Mesozoic Beds of the Coalfield of Eastern Virginia." Verhandl. k.-k. geol. Reichs. Wien, 1888, no. 10, p. 203.

Velenovský, J. (1885).—Die Gymnospermen der Böhmischen Kriedeformation. Prag, 1885.

Ward, L. F. (1905).—Status of the Mesozoic Floras of the United States. Monogr. U.S. Geol. Surv. vol. xlviii. text and atlas, 1905.

Wieland, G. R. (1906).—American Fossil Cycads. Carnegie Institution, Washington, 1906.

Wills, L. J. (1907).—On some Fossiliferous Keuper Rocks at Bromsgrove (Worcestershire). Geol. Mag. dec. 5, vol. iv. p. 28, 1907.

Zalessky, M. (1905).—Notiz über die obercarbonische Flora des Steinkohlenreviers von Jantai in der südlichen Mandshurei. Verhandl. k. Russ. mineral. Ges. St. Petersburg, ser. 2, vol. xlii. p. 385, 1905.

Zeiller, R. (1894).—Notes sur la Flore des couches permiennes de Trienbach (Alsace). Bull. Soc. Géol. France, ser. 3, vol. xxii. p. 163, 1894.

—— (1902).—Flore fossile des Gîtes de Charbon du Tonkin. Études Gîtes Minér. France, Col. franç. text and atlas, 1902–3.

Zeiller, R., et Renault, B. (1888).—Études sur le Terrain houiller de Commentry: vol. ii. Flore fossile (part i. by Zeiller, part ii. by Renault, part iii. by Renault and Zeiller). Text, 1888–90; atlas, 1888. St. Étienne.

Zigno, A. de (1873).—Flora fossilis Formationis Oolithicæ. Padova, vol. ii. 1873–85.

EXPLANATION OF THE PLATES.

(All the photographs are by Mr. Tams, Cambridge.)

Plate 17.

Fig. 1. *Zamites grandis,* nom. nov. An almost complete pinna, in which, however, a small portion of the apex is wanting. From the Keuper of Mr. Griffin's North Quarry, Rock Hill, near Bromsgrove (Worcestershire). No. 24, British Triassic Plant Coll., Sedgwick Museum, Cambridge. Half nat. size.

Fig. 2. *Zamites grandis.* A basal portion of a pinna, showing the nervation. From the same locality. No. 26 in the same collection. Nat. size.

Fig. 3. *Zamites grandis.* A large incomplete pinna. From the same locality. No. 25 in the same collection. Half nat. size.

Fig. 4. *Zamites grandis.* A basal portion of a slender pinna, showing the callosity at the point of attachment. From the same locality. No. 30 in the same collection. Nat. size.

Plate 18.

Fig. 1. *Pterophyllum Bronni,* Schenk. Five pinnæ, all probably belonging to the same frond, and a small fragment of the rachis. From the Lower Keuper of Raibl, in Carinthia. From the specimen in the Munich Museum. Two-thirds nat. size.

Fig. 2. *Zamites grandis.* Apical portion of a pinna. From the same locality as the specimens figured on Plate 17. No. 26, British Triassic Plant Coll., Sedgwick Museum, Cambridge. Nat. size.

Fig. 3. *Zamites* sp. Portion of a pinna. From the Rhætic of Phantaisie, near Bayreuth, Bavaria. No. 294, Foreign Plant Coll., Sedgwick Museum, Cambridge. Three-fourths nat. size.

Plate 19.

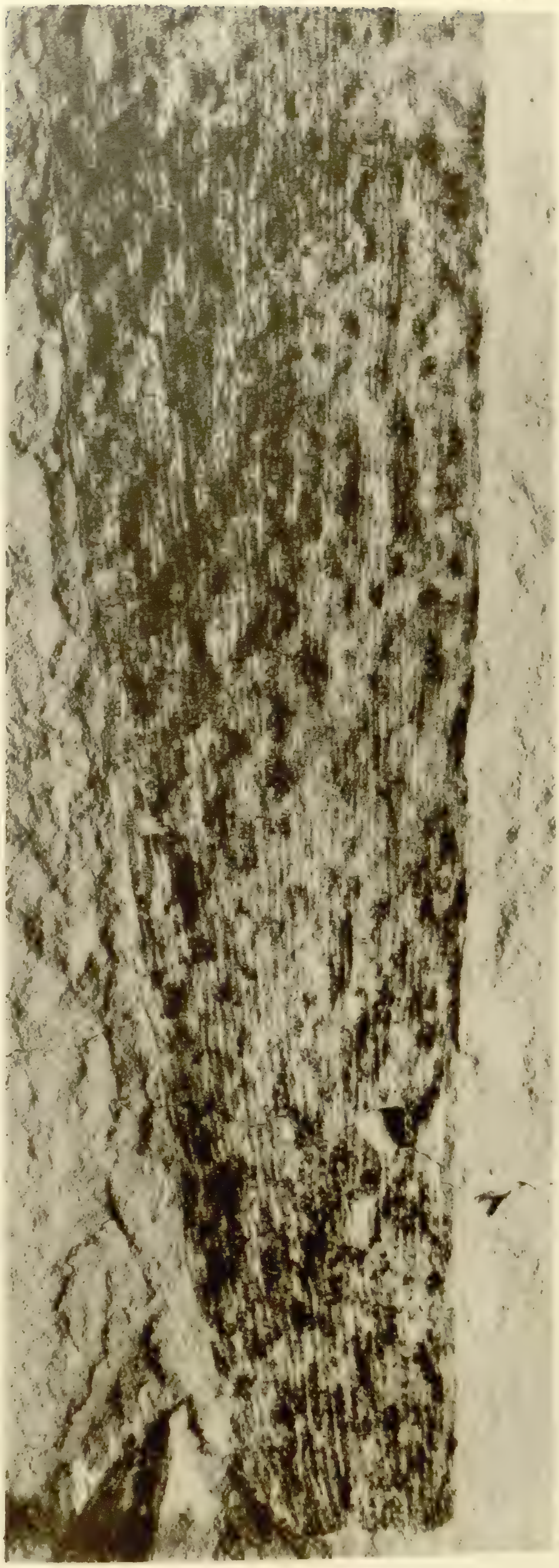
Fig. 1. *Zamites grandis.* Apical portion of a pinna, bent upon itself. From the same locality as the specimens figured on Plate 17. No. 22, British Triassic Plant Coll., Sedgwick Museum, Cambridge. Nat. size.

Fig. 2. *Zamites grandis.* Basal portion of a slender pinna, showing the callosity at the base. From the same locality. No. 28 in the same collection. Nat. size.

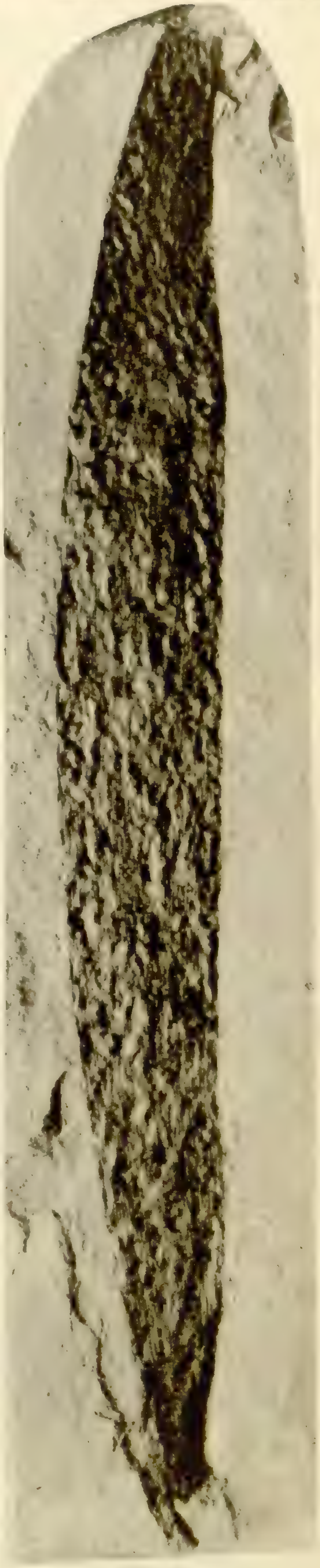
Fig. 3. *Zamites grandis.* Apical portion of a pinna. From the same locality. No. 27 in the same collection. Nat. size.

Fig. 4. *Pterophyllum Bronni,* Schenk. Three pinnæ, probably still attached to the rachis (*r.*). The nervation is clearly seen. From the Lower Keuper of Raibl, Carinthia. From the specimen in the Munich Museum. Slightly below nat. size.

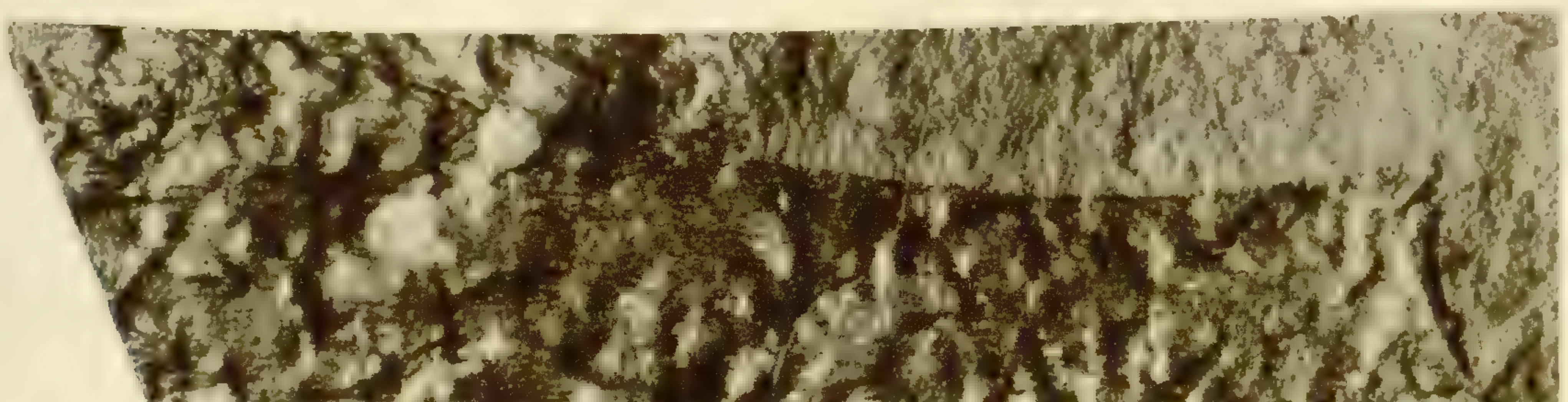
3



2



1

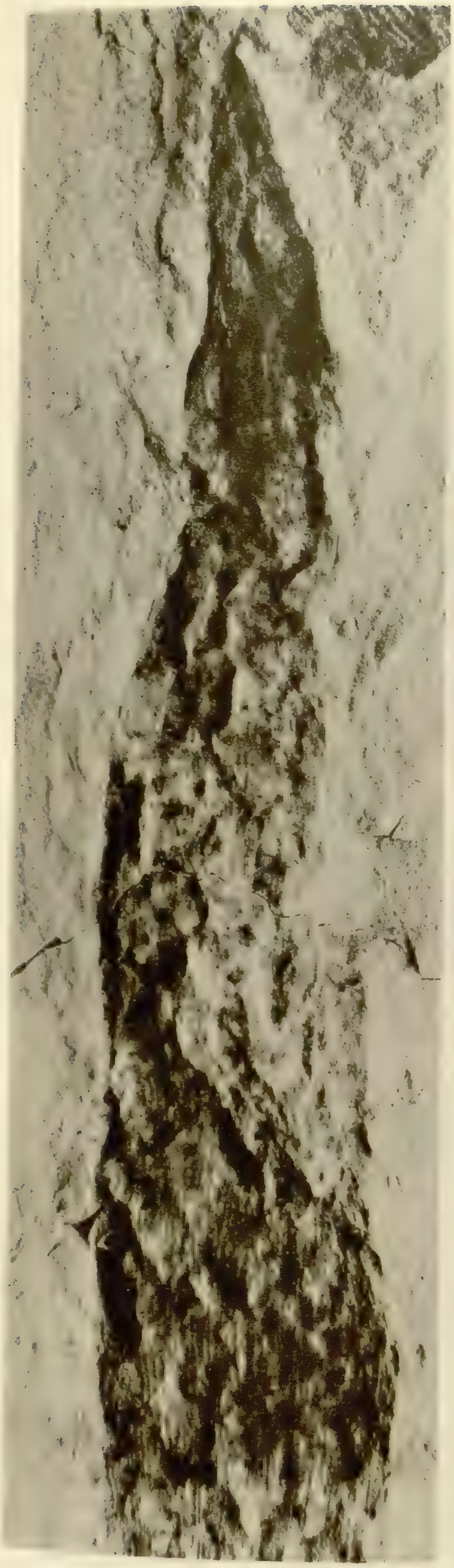


4

W. Tams photo.

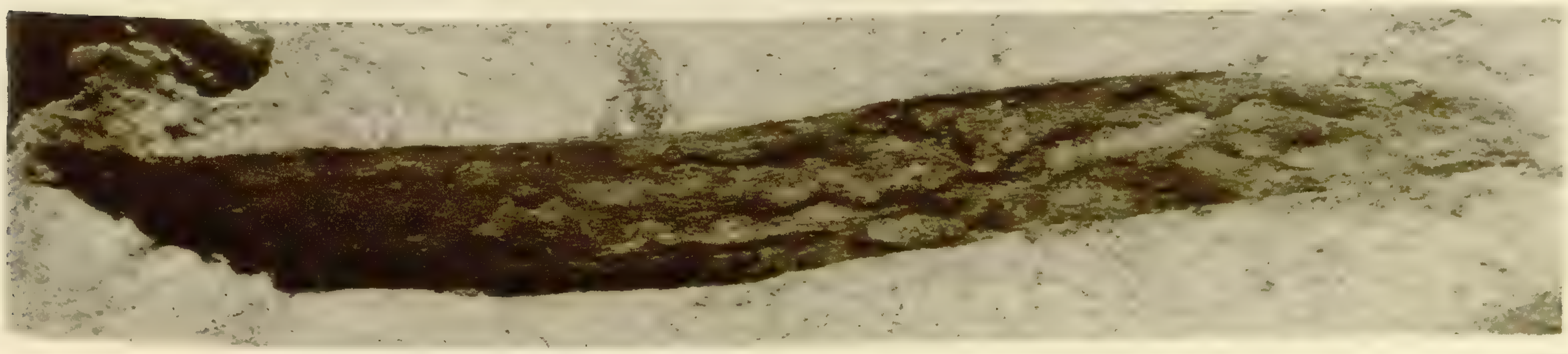
London Stereoscopic Co. imp.

ZAMITES GRANDIS, SP. NOVA



2

1

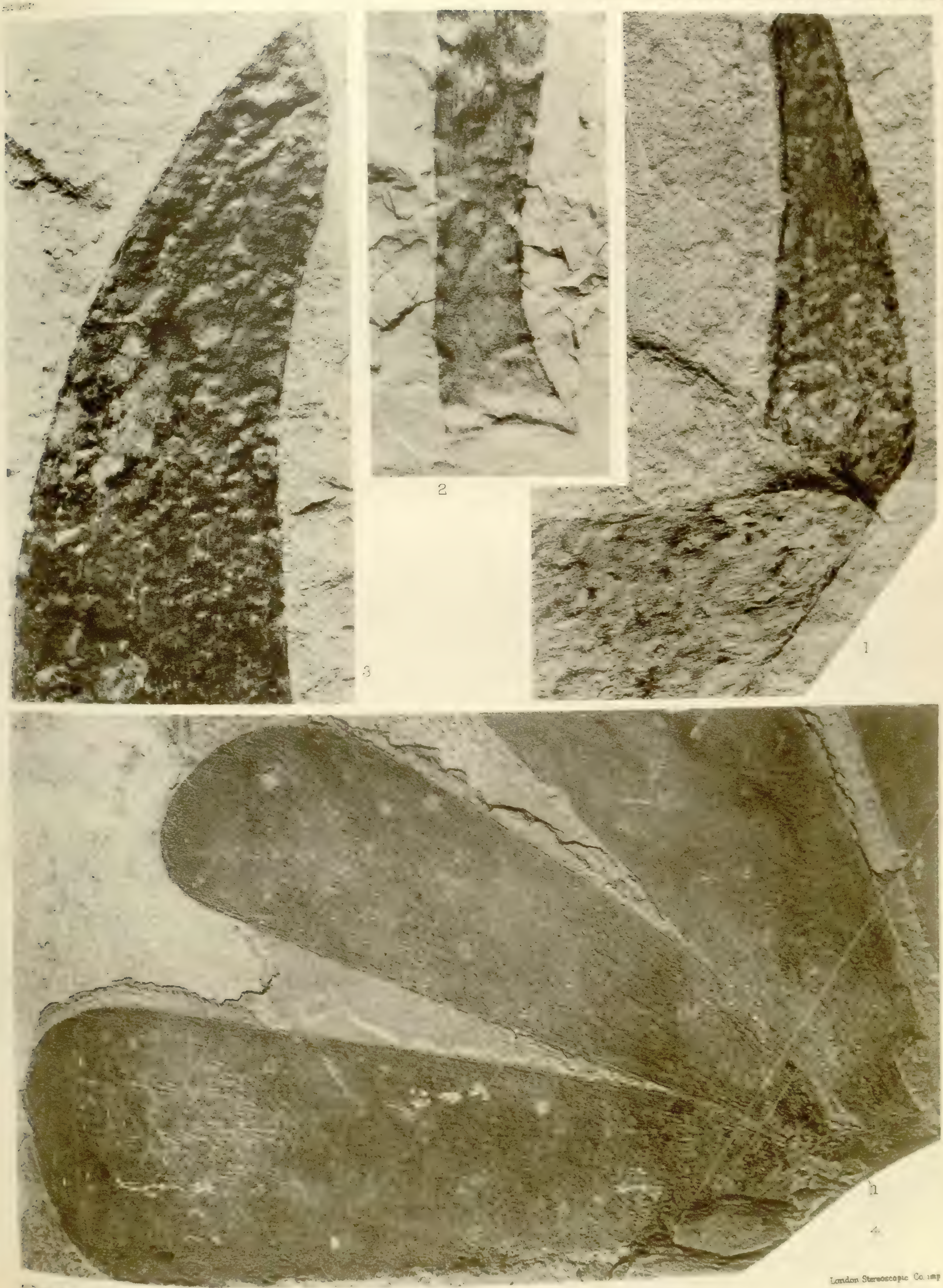


3

W. TAMS photo.

London Stereoscopic Co. imp.

ZAMITES & PTEROPHYLLUM.



G. Tams phot.

London Stereoscopic Co. imp.

ZAMITES & PTEROPHYLLUM

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s.* to the public, and 6*s.* to Fellows; to Vols. 26–30, 4*s.* to the public, and 3*s.* to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

Second Series.—Botany.

Volume.		When Published.	Price to the Public. £	*s.*	*d.*	Price to Fellows. £	*s.*	*d.*
I.	Part I.	1875	0	8	0	0	6	0
	Part II.	1875	0	16	0	0	12	0
	Part III.	1876	0	12	0	0	9	0
	Part IV.	1876	0	10	0	0	7	6
	Part V.	1878	1	4	0	0	18	0
	Part VI.	1879	1	6	0	0	19	6
	Part VII.	1880	1	4	0	0	18	0
	Part VIII.	1880	1	1	0	0	16	0
	Part IX.	1880	1	0	0	0	15	0
II.	Part I.	1881	0	12	0	0	9	0
	Part II.	1882	0	5	0	0	3	9
	Part III.	1883	0	10	0	0	7	6
	Part IV.	1883	0	3	0	0	2	3
	Part V.	1883	0	3	0	0	2	3
	Part VI.	1884	0	13	6	0	10	0
	Part VII.	1884	0	9	6	0	7	0
	Part VIII.	1884	0	10	0	0	7	6
	Part IX.	1886	0	7	0	0	5	0
	Part X.	1887	0	3	4	0	2	6
	Part XI.	1886	0	6	0	0	4	6
	Part XII.	1886	0	8	0	0	6	0
	Part XIII.	1887	1	7	0	1	0	0
	Part XIV.	1887	0	7	0	0	5	0
	Part XV.	1887	0	10	0	0	7	6
	Part XVI.	1888	0	2	6	0	2	0
III.	Part I.	1888	3	12	0	2	14	0
	Part II.	1891	0	5	0	0	3	9
	Part III.	1891	0	7	0	0	5	0
	Part IV.	1891	0	6	0	0	4	6
	Part V.	1891	0	6	0	0	4	6
	Part VI.	1891	0	3	6	0	2	8
	Part VII.	1892	0	6	0	0	4	6
	Part VIII.	1893	0	6	0	0	4	6
	Part IX.	1893	1	8	0	1	1	0
	Part X.	1894	0	10	0	0	7	6
	Part XI.	1894	0	3	4	0	2	6

Second Series.—Botany (*continued*).

Volume.		When Published.	Price to the Public. £	*s.*	*d.*	Price to Fellows. £	*s.*	*d.*
IV.	Part I.	1894	1	0	0	0	15	0
	Part II.	1894	2	0	0	1	10	0
	Part III.	1895	2	10	0	1	17	6
	Part IV.	1895	0	3	4	0	2	6
V.	Part I.	1895	0	9	0	0	6	9
	Part II.	1895	0	12	0	0	9	0
	Part III.	1896	0	6	0	0	4	6
	Part IV.	1896	1	0	0	0	15	0
	Part V.	1896	0	14	0	0	10	6
	Part VI.	1896	0	4	0	0	3	0
	Part VII.	1897	0	4	0	0	3	0
	Part VIII.	1897	0	6	0	0	4	6
	Part IX.	1899	0	12	0	0	9	0
	Part X.	1899	0	6	0	0	4	6
	Part XI.	1899	0	7	0	0	5	0
	Part XII.	1899	0	12	0	0	9	0
	Part XIII.	1900	0	1	6	0	1	2
	Part XIV.	1900	0	3	0	0	2	3
	Part XV.	1901	0	6	0	0	4	6
VI.	Part I.	1901	1	10	0	1	2	6
	Part II.	1901	0	6	0	0	4	6
	Part III.	1902	0	18	0	0	13	6
	Part IV.	1903	0	8	0	0	6	0
	Part V.	1903	0	8	0	0	6	0
	Part VI.	1903	0	12	0	0	9	0
	Part VII.	1904	0	12	0	0	9	0
	Part VIII.	1904	0	12	0	0	9	0
	Part IX.	1904	0	7	0	0	5	3
	Part X.	1904	0	14	0	0	10	6
	Part XI.	1905	0	4	0	0	3	0
VII.	Part I.	1904	0	5	0	0	3	9
	Part II.	1905	0	6	0	0	4	6
	Part III.	1906	0	3	0	0	2	3
	Part IV.	1906	0	7	0	0	5	3
	Part V.	1907	0	10	0	0	7	6
	Part VI.	1907	0	4	0	0	3	0
	Part VII.	1907	0	6	0	0	4	6

2nd Ser. BOTANY.] [VOL. VII. PART 8.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

THE ANATOMY OF THE JULIANIACEÆ CONSIDERED FROM THE SYSTEMATIC POINT OF VIEW.

BY

F. E. FRITSCH, D.Sc., Ph.D., F.L.S.,
ASSISTANT PROFESSOR OF BOTANY, UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.

LONDON:

PRINTED FOR THE LINNEAN SOCIETY
BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

January 1908.

VIII. *The Anatomy of the Julianiaceæ considered from the Systematic Point of View.* *By* F. E. Fritsch, *D.Sc., Ph.D., F.L.S., Assistant Professor of Botany, University of London, University College.*

(Plates 20 & 21 and two Text-figures.)

Read 20th June, 1907.

THE creation of a new Natural Order obviously calls for a far more careful scrutiny of the evidence from every point of view than in the case of the establishment of a new systematic unit of minor importance. The researches of the last twenty years have shown that an investigation of the anatomy of the plant often furnishes valuable characters supplementary to those obtained by a study of the external morphology, and consequently anatomical structure may be looked to, to confirm conceptions gained by such a study. In the case of a Natural Order, and especially of one of limited size, we may hope to find in the anatomy of the plant certain constant and characteristic features which will not only form a valuable addition to the exomorphic diagnosis, but may also contribute materially towards a determination of affinities. And even should an investigation of the anatomy not afford results so useful to a systematist, it is nevertheless the requisite of modern botanical science to study the plant in all its aspects, and consequently its anatomy may not be neglected. A consultation of Solereder's 'Systematische Anatomie der Dicotyledonen' will convince anyone that our present-day knowledge of Phanerogamic anatomy, though it has made extensive progress in the last twenty years, is totally inadequate. Systematists are beginning to recognise the necessity of remedying this state of affairs, but the task that lies before them is an enormous one. Before we may expect to have an adequate knowledge of the detailed anatomy of the vast number of Phanerogams, the external morphology of which is more or less completely studied, many years will have to elapse. In the meantime, however, we must guard against adding to the mass of uninvestigated material; when new forms are described we should strive as far as possible to include anatomical details in the description. Recognising this fact, I was only too glad at Mr. Hemsley's suggestion to undertake an investigation of the anatomy of the two genera *Juliania*, Schlecht., and *Orthopterygium*, Hemsl., which form his new Natural Order Julianiaceæ *. The outcome of this investigation constitutes the subject of the present paper. It was

* "On the Julianiaceæ: a new Natural Order of Plants," Phil. Trans. Roy. Soc. London, ser. B, vol. 199, 1907, pp. 169–197, plates 18–24; also Proc. Roy. Soc. ser. B, vol. 78, 1906, pp. 231–236. For the sake of brevity, the frequent references to Mr. Hemsley's paper are made in the form of "Hemsley, p. —," without further citation of the title; the first of the two papers just cited is always that referred to.

commenced at the Jodrell Laboratory, Royal Botanic Gardens, Kew, and was concluded at University College.

Anatomy has already played some part in the discussion as to the systematic position of the genus *Juliania* of Schlechtendahl, but unfortunately a grave source of error was thereby introduced in this case. In 1894, in the course of an investigation into the structure and affinities of the Anacardiaceæ, Jadin * dealt with the anatomy of *Juliania*; he sums up his results as follows: —"Par la présence de canaux sécréteurs dans la moëlle ce genre parait devoir prendre place parmi les Simarubacées; l'absence de canaux sécréteurs libériens ne permet pas de le considérer comme une Térébinthacée." These results are totally at variance with those which I have obtained in the present investigation, and I have no doubt that the plant which Jadin examined was not a member of the Julianiaceæ at all; possibly it was one of the Simarubaceæ. Apart from the fact that secretory canals are *not* found in the pith of the stem in all Julianiaceæ, their occurrence in the phloem is an absolutely constant feature throughout all the parts of the plant I have examined. In fact, the canals are so excessively abundant that they could never have been overlooked. Jadin's statements are repeated by Solereder †; *Juliania* is dealt with under the Anacardiaceæ, but its transference to the Simarubaceæ is supported. Since Jadin's remarks have been shown to be due to an error, there is nothing further in the anatomical structure that affords particular evidence of Simarubaceous affinity, and from our point of view such an affinity need no longer be considered; nor do exomorphic characters, so far as I am aware, in any way lend support to such a view.

In his account of the Julianiaceæ, Mr. Hemsley ‡, in speaking of the affinities of the Order, states that the morphological characters evidence closest relationship with the Anacardiaceæ and Cupuliferæ. In the type of foliage, viz. alternate, exstipulate, imparipinnate leaves, we also have a point of resemblance to Juglandaceæ, and there are some other morphological features common to the two Orders (diœcious flowers with dissimilar male and female flowers, the single integument of the ovules, &c.). These cannot, however, "be regarded as constituting a close affinity" (Hemsley, p. 191), and as far as the anatomy is concerned there is no support for such a view at all. The Juglandaceæ are characterised § by the possession of peltate external glands accompanied by simple unicellular hairs, and by a somewhat extensive development of parenchyma in the secondary wood. These are features which are not found in any of the Julianiaceæ; moreover, in special contrast to the latter Order the Juglandaceæ are without any type of internal secretory organ ‖. Mr. Hemsley (p. 191), in discussing

* Jadin, "Recherches sur la structure et les affinités des Térébinthacées," Ann. Sc. nat. sér. 7, t. xix. 1894, p. 50.

† Solereder, 'Systematische Anatomie der Dicotyledonen' (Stuttgart, 1899), pp. 278 & 281.

‡ Hemsley, 'On the Julianiaceæ, a new Natural Order of Plants,' *loc. cit.* p. 191.

§ *Cf.* Solereder, *loc. cit.* p. 881.

‖ It may be pointed out that the Leitnerieæ, which are placed in the Juglandales by Engler and in the Unisexuales by Bentham and Hooker, show one or two points of anatomical agreement with the Julianiaceæ; thus they possess medullary secretory canals, a somewhat similarly constructed wood, subepidermal cork-development, and hairs of an analogous type. There are, however, also very pronounced anatomical differences. The Leitnerieæ also have a unilocular ovary with a single ovule.

the relationships of Julianiaceæ and Juglandaceæ, states that the latter are resiniferous; the resin is here, however, contained in the cells and not in special secretory receptacles, as in Julianiaceæ and Anacardiaceæ (*cf.* Engler, in Natürl. Pflanzenfam. iii. 1, p. 21).

The anatomy gives evidence of a far closer relationship to Anacardiaceæ (Hemsley, p. 191). In the first place, the resin-canals mentioned above are an indication of close affinity; they occur in just the same position as in the Anacardiaceæ, being invariably found in the phloem throughout the plant. In the Julianiaceæ resin-canals are also present in the primary cortex in all cases; this is not the rule in the Anacardiaceæ, but canals are found in this tissue in some Anacardiaceous genera. The presence of canals in the pith is not an absolutely constant feature in either Order. The mode of development of these secretory organs is the same in the two cases. A further point of resemblance between Anacardiaceæ and Julianiaceæ is to be found in the peculiar external glands of the latter, which are very much like those of a *Dobinea* for example *. Reference to Solereder and to the section of this paper dealing with the structure of the stem will show that the wood is very similar in the two Orders. The place of development of the cork is also the same in both cases. In fact, there is so much resemblance in the anatomy between the two Orders that it is difficult or almost impossible to separate them on anatomical grounds,—the more so as the anatomy of the leaf in the Anacardiaceæ is but very imperfectly known. It is possible that when we know more about the latter point some distinguishing character may become evident; perhaps the almost complete absence of sclerenchyma in the vegetative organs of the Julianiaceæ and the prevalence of clustered crystals may be found to be of value in this respect.

It still remains to consider the Cupuliferæ. Anatomical structure does not encourage the view of a close affinity of the Julianiaceæ with this Order. The Cupuliferæ have no internal secretory elements; the structure of the wood is very different in the two cases; the pericycle contains a sclerenchymatous ring in the Cupuliferæ, &c. On the other hand, there are a few points of resemblance (absence of subsidiary cells to the stomata, occurrence of glandular hairs which are in some cases a little like those of the Julianiaceæ, subepidermal cork-development), but these are of little importance in view of the absence of the main characters.

The previous paragraphs may be briefly summarised by stating that the Julianiaceæ in their anatomical structure show a most marked affinity to the Anacardiaceæ,—so marked, indeed, that it is difficult to hold the two Orders distinct from this point of view. Yet in the external morphology Mr. Hemsley finds so many striking points of difference that he comes to the conclusion that the balance is in favour of a Cupuliferous affinity of the Julianiaceæ †. It seems, however, that the Julianiaceæ in their external morphology show a decided correspondence neither to the Cupuliferæ nor to the Anacardiaceæ. In coming to his conclusion Mr. Hemsley has perhaps laid too much weight on outward resemblance of the inflorescence, &c., to corresponding structures in

* *Cf.* Radlkofer, in Sitz.-Ber. Akad. der Wissensch. München, Bd. xviii. 1888, p. 388; also Solereder, *loc. cit.* pp. 278, 279.

† Hemsley, p. 192.

the Cupuliferæ. As far as ovary and ovule are concerned there is considerable agreement with the Anacardiaceæ, the most essential difference being the single integument of the ovule in the Julianiaceæ (Hemsley, p. 191). There is, however, certainly little in the morphology of the Julianiaceæ that speaks markedly in favour of one or other view. We have therefore to decide whether a complete anatomical correspondence is to bear more weight than a certain degree of morphological resemblance, or, in other words, whether the close similarity between the anatomy of the Julianiaceæ and Anacardiaceæ is a point of greater importance than the limited morphological resemblance between Julianiaceæ and Cupuliferæ.

In considering this question it is well to turn our attention for a moment to the general value of those anatomical characters which constitute the main point of resemblance between Julianiaceæ and Anacardiaceæ. Secretory canals are known to be characters which generally appertain to a fairly wide systematic group: as examples I may mention the resin-canals of the Coniferæ, of the Umbelliferæ and Araliaceæ, and of the Hypericineæ and Guttiferæ. Similar examples could be adduced in the case of other secretory elements, such as secretory cells, mucilage-cells, mucilage-ducts, &c. On the other hand, we occasionally find an Order or certain members of an Order possessing some characteristic secretory organ which is completely wanting in closely allied Orders or in other members of the same Order; examples of this kind are specially noticeable in the case of laticiferous tissue, but other examples are not difficult to find. Thus a considerable number of the Rhamneæ are characterised by the possession of mucilage-receptacles in stem and leaf; but these are practically unknown in the related Celastrineæ and Hippocrateaceæ. On the whole, however, secretory organs tend to characterise large systematic groups, and may consequently be looked upon as an indication of affinity of some importance. Similar considerations on the distribution of glandular hairs would lead one to an analogous result. As regards the structure of the wood, such a complete correspondence as exists in the case of the Anacardiaceæ and Julianiaceæ is bound to be of importance in considering affinities, especially when supported by other characters.

We must therefore come to the conclusion that the points of anatomical similarity between Anacardiaceæ and Julianiaceæ are no trivial ones, and cannot be neglected. The weight of anatomical evidence cast into the scale-pan of the exomorphic indications of Anacardiaceous affinity must more than counterbalance any slight excess of morphological resemblance on the side of the Cupuliferæ. An assumption of an Anacardiaceous affinity for the Julianiaceæ need not, of course, lead to a rejection of Cupuliferous affinities; but it seems to me impossible to regard the Julianiaceæ as being more closely allied with any other Order than they are with the Anacardiaceæ.

Before passing on to special considerations I should like to take this opportunity of cordially thanking Mr. Hemsley for the material which he kindly placed at my disposal. This material was of necessity somewhat limited, especially in the case of some of the species; and that may be my excuse for any imperfections contained in the following detailed description of the anatomy of the Julianiaceæ. I have endeavoured to deal with all the different parts of the plant (the root, of which no material was available, alone

excepted), although in some cases my statements are limited to a single species. The illustrations are the work of my wife.

The following description deals successively with the leaf, stem, inflorescence, fruit, and embryo. The anatomical diagnosis of the two genera and five species may serve as a final summary.

(i.) The Leaf.

The leaves of the Julianiaceæ (Hemsley, pp. 175 & 181) are imparipinnate, alternate, and exstipulate; they form clusters at the tips of the flowering branches, the stem for some distance behind its apex being covered completely by the bases of the petioles; the lowest portion of the latter is adnate for a short distance to the stem. Disarticulation of the leaves takes place a little way above the point of attachment of the petioles, so that older parts of the stem bear a covering of persistent and often somewhat woody leaf-bases. In addition to the clusters found at the tips of the flowering branches, scattered leaves occur on the barren shoots as well.

In such a closely related group as is constituted by the members of this Order, the anatomical characters of the leaf show considerable uniformity, although there are, in most cases, sufficiently pronounced differences to admit of specific distinction. The presence of uni- or multicellular hairs, not infrequently forming a dense covering on the lower or on both surfaces of the pinnæ, and of glandular hairs of varied shape but conforming to a general type are two characteristic features in the anatomy of the leaves of the Julianiaceæ; but equally important are the large resin-canals, which are invariably found in the phloem of the vascular bundles. Other anatomical characters of the leaf, in which the different members of the Order agree, are as follows:—the absence of a hypoderm and of gelatinisation of the epidermis; the lack of subsidiary cells to the stomata; the deposition of oxalate of lime solely in the form of clustered crystals; the presence of a single layer of often much elongated palisade-cells beneath the upper epidermis; the absence of sclerenchyma accompanying the vascular bundles of the veins. The most important points of distinction are found in the structure of the clothing and glandular hairs and in the nature of the cuticle.

(a) *The Lamina.*

Before dealing with the details of the anatomical structure of the lamina, it may be well to point out that the colour of the dried pinnæ is to some extent characteristic. This is particularly so in the case of the specimens of *Orthopterygium Huaucui* which I have seen; the upper surface is of a dark brown colour, while the lower surface is pale brown. In *Juliania mollis* the abundant hairy covering on the lower side of the pinnæ gives them a whitish-green appearance, quite distinct from that of the other species. *J. glauca*, as the specific name indicates, is glaucous on the lower side of the pinnæ and is further characterised by being practically glabrous.

The *epidermal cells* on the upper side of the leaf are of medium size (about $19 \times 38\,\mu$, fig. 1, C, p. 136). In surface-view they are more or less polygonal in outline, the lateral margins, though occasionally somewhat bent to and fro, never being markedly

undulate; in transverse section they are more or less quadrate, or somewhat elongated in the plane of the leaf. The lower epidermal cells are smaller than those of the upper side, but generally have the same shape, although somewhat flatter in transverse section. In certain specimens of *Juliania adstringens* (Rose and Hay, 5341) the upper epidermal cells in a transverse section show slight elongation in a direction at right angles to the surface of the leaf, *i. e.*, they are rectangular in shape; as a consequence, the surface-view of the epidermis shows rather smaller cells than in the other cases. This peculiar shape is probably related to some special condition of the habitat, which it is at present impossible to define: this is not the only peculiarity exhibited by the leaf in these specimens of *J. adstringens* (*cf.* below). Returning to the general characters of the epidermal cells, it may be noted that they are not very strongly thickened; the lateral walls are thin and the outer walls only slightly thickened (except in *J. amplifolia* and *J. mollis*). The latter are often slightly arched outwards, especially near the veins. There is a well-marked cuticle, which in most cases is very distinctly striated (not shown in figs.); it is smooth, however, in *Orthopterygium Huaucui*. In *Juliana glauca* the marking of the cuticle amounts almost to the formation of cuticular ridges having a very irregular course; on the lower epidermis these cuticular ridges project to some extent over the guard-cells of the stomata, forming a kind of fringe around them. The cuticle often exhibits a tendency to split away from the rest of the section, this being specially noticeable in *J. glauca*.

The *stomata* (fig. 1, A, B, D) are relatively large, being about 30 μ in length; in surface view they are often rather elongated. There are no subsidiary cells. The mother-cell of the guard-cells in *J. mollis* is cut off by the first division-wall, and this is probably true of all the members of the Order. The stomata are frequently raised a little above the level of the surrounding epidermal cells; they are confined to the lower epidermis, except in *J. adstringens*, in which scattered stomata are occasionally found on the upper side of the leaf as well (Nelson, 1827).

The most prominent feature of the epidermis is its *appendages* (fig. 1); long multicellular clothing-hairs and small, delicate, glandular hairs are found on both surfaces of the leaf, although generally more abundant on the lower. They constitute a plentiful hairy covering in all but *Juliania glauca*, in which the clothing-hairs are only of isolated occurrence. The *clothing-hairs* (fig. 1, A, C, D) are entirely unbranched and as a rule multicellular, consisting of from two to many cells; hairs composed of a large number (10 or more) of cells are particularly characteristic of *J. mollis*, whilst smaller numbers (4 or 5) of cells form the trichomes of *J. adstringens* and *J. amplifolia* (fig. 1, C). In *Orthopterygium Huaucui* (fig. 1, D) the hairs for the most part consist of two cells only and frequently show a further reduction to the unicellular condition; unicellular hairs also occurred quite commonly amongst the multicellular ones in some specimens of *Juliania adstringens* (Rose and Hay, 5341). The hairs either stand out stiffly from the epidermis (fig. 1, A) or are curved in various ways (fig. 1, C, D). The former type is found in *J. amplifolia* and *J. mollis*; they have long hairs tapering very gradually to a point and often slightly curved at the apex (fig. 1, A); the lateral walls of these trichomes are thick and surround a well-marked lumen, which is divided up into a number of

compartments by relatively thin septa. The basal portions are much thickened and swollen, and are sunk in amongst the surrounding epidermal cells, which show a more or less distinct radial arrangement; the sunken base of the hair not rarely projects a short distance into the subjacent mesophyll. The cuticle of the surrounding epidermal cells is slightly raised to form a kind of collar around the base of the hair (fig. 1, A), and this collar is apparently not continuous with the cuticle of the upper part of the hair. Below this point the trichome is sometimes slightly narrowed before expanding into the swollen basal portion. The wall of the hair bears simple slit-shaped pits, which are most prominently developed in the lower part (not figured). Towards the pointed apex the lumen of the hair often disappears entirely and the hair becomes solid. Curved trichomes are characteristic of *J. adstringens* and are occasionally found also in *J. amplifolia*; they have rather thinner walls than the straight hairs just described and have a more or less undulated outline; otherwise they agree in structure with the hairs of *J. amplifolia* and *J. mollis*. The trichomes of *Orthopterygium*, as above mentioned, are prevalently bicellular and occasionally unicellular. They are, on the whole, far shorter than the type of hair found in *Juliania*, and do not run out to such a sharp point; they are rarely straight, more commonly curved towards the one side or other (fig. 1, D), and the walls are relatively thin. There is no well-marked cuticular collar, and the sunken base of the hair is very little swollen. The base of the hair is invariably provided with simple pits (not figured), the latter sometimes also occurring on the wall of the projecting portion of the trichome. Another point of difference between *Juliania* and *Orthopterygium* lies in the distribution of the hairs; in the former genus they are practically confined to the veins (even in the very hairy *J. mollis*), while in *Orthopterygium* they are distributed fairly uniformly over the surface of the leaf.

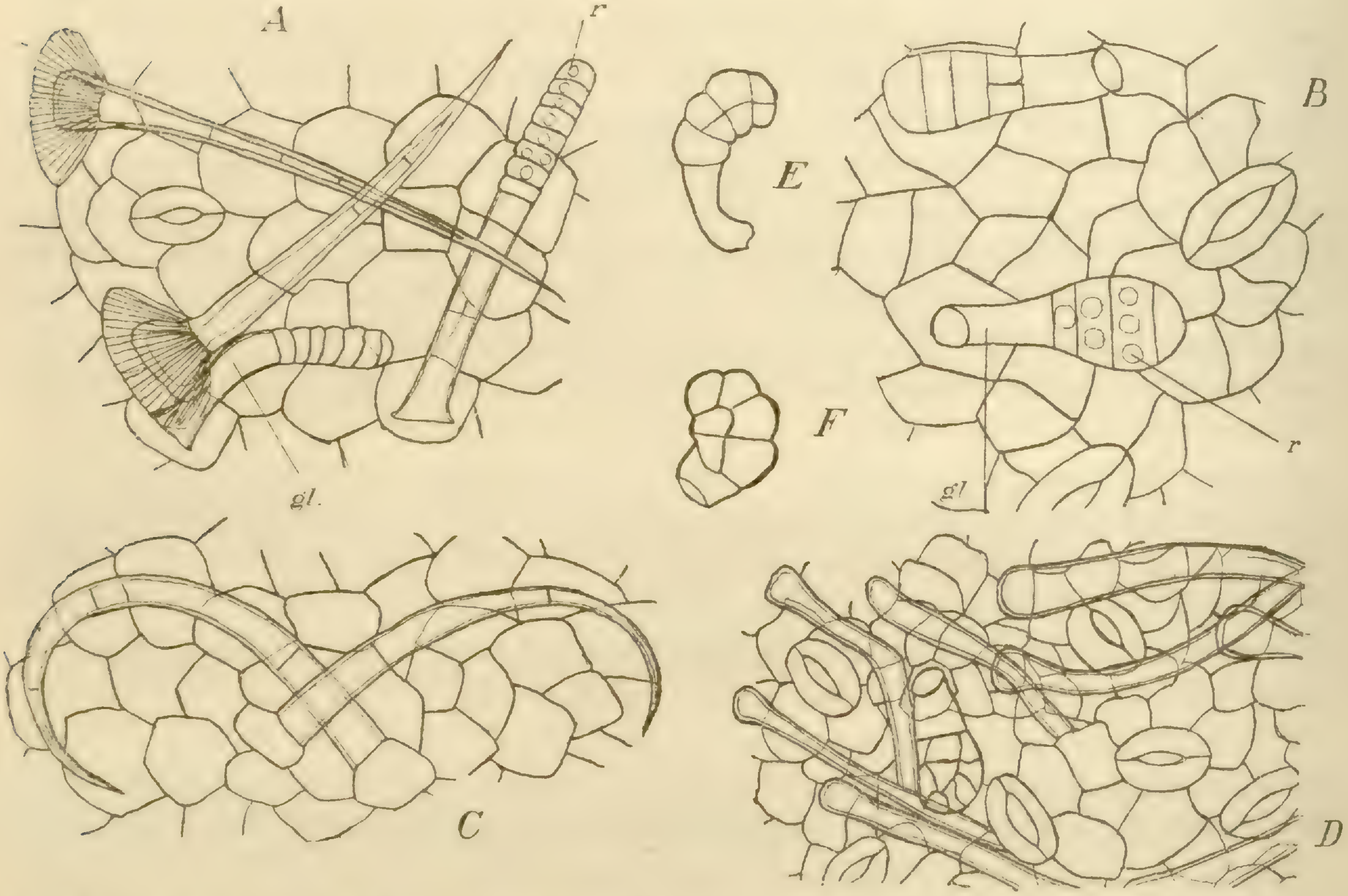
In amongst the clothing-hairs the *glands* (*cf.* fig. 1, p. 136) are scattered. These glandular hairs are found in all the members of the Order and in about equal abundance, and although they show a certain amount of diversity there is a general ground-plan underlying their structure, which makes them an important character for the diagnosis of the Order. They are found in about equal numbers on both surfaces of the leaf and occur uniformly distributed all over the epidermis. In appearance these glands are very much like those of some Anacardiaceæ, e. g. *Dobinea* *. They are always provided with a stalk composed of a single row of one or two, more or less elongated cells; upon this the actual body of the gland is borne. The stalk of the glands is directly attached to a single epidermal cell and is in no way sunk, as is the case with the base of the clothing-hairs (fig. 1, A, B); the epidermal cells surrounding the one from which a gland arises sometimes exhibit a more or less distinct radial arrangement. The body of the gland is very commonly not a straight continuation of the stalk, but is more or less curved—frequently so much so that the apex comes to lie in close proximity to the stalk (fig. 1, E, F). As a rule, the gland proper is of somewhat larger diameter than the stalk; it consists of a number of short, flat cells, which frequently exhibit further subdivision by vertical walls, *i. e.*, the glands have a multicellular head with horizontal and vertical division-walls. In many cases the secretion was still well

* *Cf.* Solereder, 'Systematische Anatomie der Dicotyledonen,' 1899, pp. 278, 279.

preserved; it is found in all the cells of the head in the form of globular drops of an opaque yellowish-white appearance (fig. 1, A, B), one or more drops being present in each cell; the secretion is insoluble in Eau de Javelle, absolute alcohol, and xylol.

In *Juliania amplifolia* the glands have a fairly long unicellular stalk and an oval elongated head, in which vertical division-walls are comparatively rare (fig. 1, B); the

Fig. 1.



A.—*Juliania mollis* (Pringle, n. 6871), surface-view of lower epidermis, showing stomata, clothing-hairs, and two glandular hairs, one of them with resinous contents (*r*). (× 200.)

B.—*J. amplifolia* (Rose & Hough, n. 4755), lower epidermis with stomata and two glandular hairs, one of them with resinous contents (*r*); clothing-hairs omitted. (Cuticular striation not shown.) (× 360.)

C.—*J. amplifolia* (Rose & Hough, n. 4755), surface-view of upper epidermis, showing bent, multicellular clothing-hairs. (Cuticular striation not shown.) (× 360.)

D.—*Orthopterygium Huaucui*, surface-view of lower epidermis, showing stomata, unicellular hairs, and a glandular hair. (× 305.)

E.—*Juliania adstringens* (Pringle, n. 7243), a detached glandular hair. (× 290.)

F.—*Orthopterygium Huaucui*, a detached glandular hair. (× 360.)

diameter of the head frequently only slightly exceeds that of the stalk. In *J. mollis* the glands tend to be more elongated than in *J. amplifolia*, the glandular portion having very much the same diameter as the stalk; the latter consists of one or two much-elongated cells contrasting greatly with the often numerous short cells which constitute the head; vertical division-walls are rare in the latter (fig. 1, A). It is only the markedly

elongated gland of *J. mollis* that is really characteristic; very often there is a preponderance of short glands, which are very like those of *J. amplifolia*. In *J. glauca* and *J. adstringens* (fig. 1, E) the glands rather resemble those of *J. amplifolia* in shape, but the actual glandular portion is mostly well demarcated and vertical division-walls are rather common; in some cases they show a definite arrangement, so that the glandular portion consists of four-celled tiers. In *Orthopterygium Huaucui* the glandular hairs are rather distinctive; they are, on the whole, very short and somewhat globular in shape, with a much reduced unicellular stalk. The globular multicellular head exhibits both horizontal and vertical division-walls, which often divide it up into a number of alternating tiers of four cells each (fig. 1, D, F).

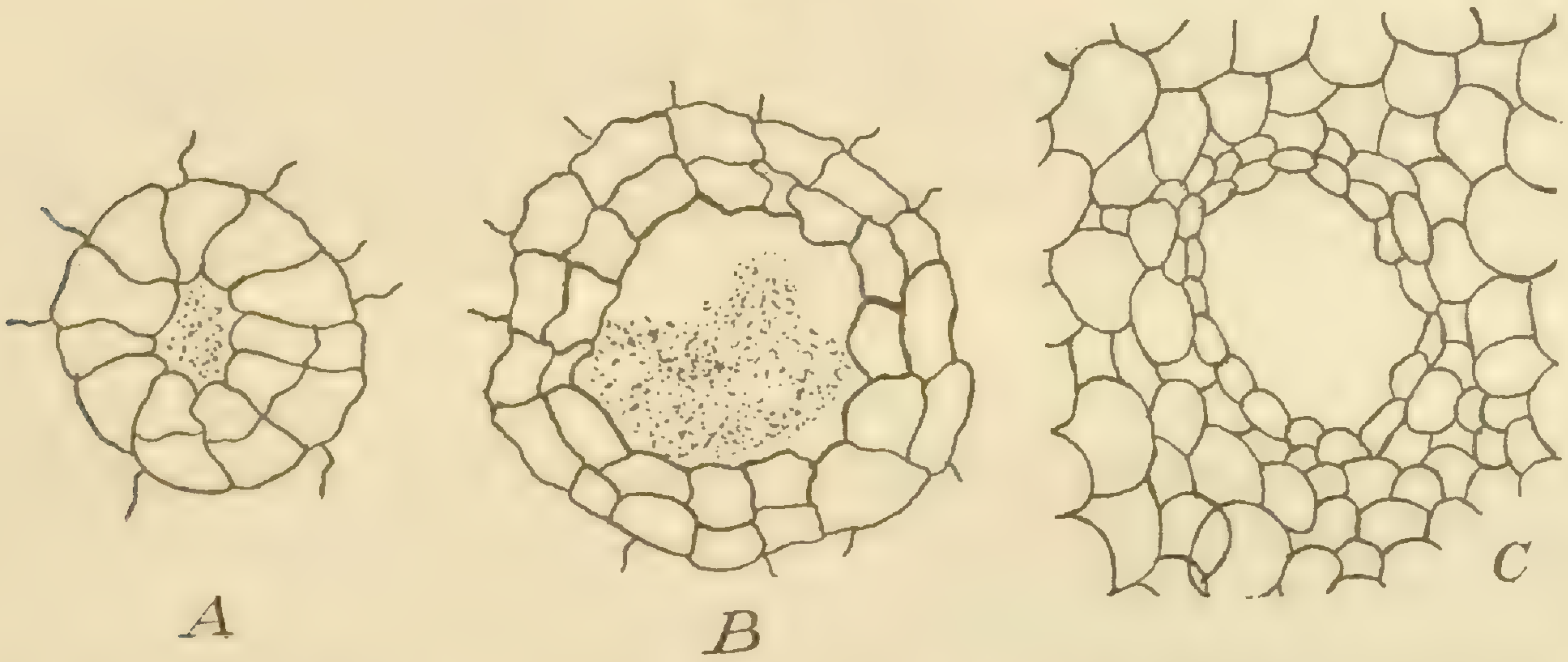
The *mesophyll*, as a rule, shows a well-marked differentiation into palisade and spongy tissue, although in *Juliania mollis* and *J. adstringens* the lower layer of the spongy tissue tends to develop into palisade. The ordinary palisade-tissue in all cases consists of a single layer of cells, which are much elongated and have a very small diameter. The lateral walls are finely undulated in *Orthopterygium*. Seen from the surface the palisade-cells appear small and round; in *O. Huaucui* there are palisade-cells of two more or less distinct sizes.—The spongy tissue is, as a rule, rather dense and is not infrequently present only in small quantity, the palisade-tissue occupying a much greater portion of the width of the leaf than the spongy tissue. The lowest layer of the latter generally shows a somewhat palisade-like elongation, which, as above mentioned, is well pronounced in *Juliania mollis* and *J. adstringens*. In some specimens of the latter species (Rose and Hay, 5341) no proper spongy tissue is developed; on the lower side of the leaf there are two layers of palisade consisting of short rounded-rectangular cells, which are much wider and shorter than the ordinary palisade-cells below the upper epidermis. The upper epidermal cells in these same specimens, as will be remembered (*cf.* p. 134), have a slightly columnar shape. In this way the entire transverse section of the leaf acquires a very characteristic stratified appearance, which is slightly represented in all the members of the Order.

Scattered about in the mesophyll are large clustered *crystals* of varied shape, which generally occupy somewhat enlarged idioblasts. The latter are mostly found lying immediately beneath the upper and lower epidermis, and are in most cases confined to the neighbourhood of the numerous small veins of the leaf; in *Orthopterygium* they are also met with round about the bases of some of the hairs. A considerable number of clustered crystals are generally present also in the collenchyma forming the ribs of the larger veins; this is especially the case on the lower side of the leaf, on which the course of the veins is often marked by the numerous crystals. In *Juliania amplifolia* and *J. adstringens* the clustered crystals are particularly large and occupy correspondingly large idioblasts. No other form of excretion of oxalate of lime is met with in the leaf.

Turning, lastly, to a consideration of the vascular system of the leaf, we meet with one of the chief points of resemblance between this Order and the Anacardiaceæ. I refer to the occurrence in the phloem of large canals containing resin. This character is common to all the five species of the Julianiaceæ, the *secretory canals* even being present in the finer ramifications of the vascular system, which traverse the leaf in all directions.

Two species of Anacardiaceæ (viz. *Rhus simulata* and *Spondias mangifera*), which I examined for comparison, both possess such resin-canals in the leaf in exactly the same position. The canals are restricted to the phloem of the vascular bundles and are not found elsewhere in the tissue of the leaf. The cavity of the resin-canals is lined by a single well-marked layer of thin parenchymatous cells, appearing more or less rounded in a transverse, and slightly elongated in a longitudinal section. The mode of development of the canals is apparently schizogenous (*cf.* fig. 2, A & B, of the petiole). The contents appear as a yellowish or reddish-brown mass insoluble both in Eau de Javelle and in alcohol. One such canal is present in the bast of each vascular bundle, and, where the veins comprise a number of bundles, there is a corresponding number of resin-canals.

Fig. 2.



A, B.—*Juliania adstringens* (Rose & Hough, n. 5341), resin-canals from the petiole in transverse section, showing stages in their development.—A, early stage; B, more advanced stage. (× 680.)
C.—*Juliania glauca*, resin-canal from the pith of the stem, in transverse section. (× 215.)

The chief *veins* of the leaf, except in *Orthopterygium*, usually have well-developed collenchymatous ribs projecting on the under side. There are only a few xylem-vessels present, and the greater part of the phloem is occupied by the resin-canals, so that the amount of vascular tissue in each bundle is small. This is compensated for by the rich ramification of the vascular system, giving rise to the numerous small bundles seen in a transverse section and consisting largely of spiral tracheids. In *Orthopterygium* many of these elements have enlarged terminations. The phloem commonly contains small clustered crystals. There is never any sclerenchyma accompanying the bundles, such mechanical elements being completely absent from all parts of the leaf.

(b) *The Petiole and Rachis.*

The structure of petiole and rachis could only be examined in *Juliania adstringens* (Rose & Hay, 5341) and *Orthopterygium Huaucui*. There are no very marked differences between the two cases, and the structure shows very little variation in different parts of the rachis. The most noticeable features are the large number of resin-canals and the entire absence of sclerenchyma.

The epidermis in transverse section consists of quadrate cells, which are more or less arched outwards; it bears numerous clothing and glandular hairs, which are, on the whole, of the same type as those occurring on the lamina *. The petiole of *Orthopterygium*, however, bears occasional long undulating clothing-hairs with thin walls scattered in amongst the numerous typical hairs. The outer part of the cortex is parenchymatous and, in the case of *Juliania adstringens*, includes numerous small resin-canals arranged in a more or less irregular row a little way beneath the epidermis; many of these canals were still in process of formation and the figures illustrating their development (fig. 2, A, B) were drawn from these sections. The young secretory canal consists of a small cavity with granular contents; this is formed by the separation of the surrounding thin-walled cells, which exhibit a radial arrangement and are somewhat columnar in shape. Subsequently division-walls parallel to the contour of the cavity appear in this layer of cells, so that the cavity is surrounded by two layers of quadrate cells with thin walls. This original structure becomes more or less obscured later on, owing to further divisions taking place in the cells surrounding the cavity. The absence of such cortical resin-canals in the petiole of *Orthopterygium* may prove to be a point of generic distinction, but it may possibly be due to the petiole examined being a young one. It also remains to be seen whether cortical canals are found in the petiole of other species of *Juliania*.

The inner portion of the cortex is formed by several layers of well-differentiated collenchyma; the cells, like those of the outer parenchymatous portion of the cortex, have strongly undulated walls, which are generally much contracted. Between the collenchyma and the phloem of the vascular bundles a number of layers of much larger cells are developed, especially in *Juliania adstringens*. A small number of clustered crystals are generally scattered through the cortex.

The pith of the petiole is surrounded by a zone of vascular bundles which differ slightly among one another in size. Near the base of the petiole these vascular bundles are arranged to form an arc-shaped group, the convex surface of the arc being directed downwards, whilst the free ends are bent in towards the concave surface; the shape is like that of a broadly opened **V** with the free ends turned inwards. At the upper end of the petiole, immediately below the insertion of the first leaflets, we have a ring of bundles due to the joining up of the inverted ends of the original arc; the dorsiventrality of the vascular structure is, however, indicated by the concavity of the upper portion of the ring. The vascular bundles are separated from one another by rather narrow rays and, as above mentioned, vary slightly in size; at the upper end of the petiole there is a large flat bundle occupying the upper side of the vascular ring.

The vessels forming the xylem of the petiolar bundles have rather wide lumina. In the phloem of each bundle a resin-canal is situated, which is of much larger size than the cortical canals of *Juliania adstringens*. These resin-canals of the phloem have a large cavity and are surrounded by several layers of thin quadrate cells, the innermost

* In the case of *Juliania adstringens* the petiolar glands are much more elongated than those on the lamina. The stalk is long and consists of 2 (or sometimes even 3) cells and the glandular head is provided with a considerable number of vertical division-walls.

of which are commonly in a state of disorganisation. In this stage, therefore, the further development of the canals is apparently lysigenous. According to Sieck * such schizolysigenous secretory canals occur also in the Anacardiaceæ. In the Julianiaceæ, however, lysigeny only appears to set in in older stages, since the smaller canals in the lamina and in the petiolar cortex are purely schizogenous. Besides the regular canals of the phloem, which lie opposite to the xylem-groups of the bundles, other (generally smaller) canals are found lying between the ordinary ones; these stand in no evident relation to the bundles and are possibly of later development. The phloem of the petiolar bundles of *Orthopterygium* contains numerous clustered crystals.

Resin-canals are also present in the pith of the petiole in *Juliania adstringens*.

The structure of the *rachis* (*i.e.* of the part of the central axis of the leaf bearing the leaflets) is very much like that of the petiole. The bundles form a complete somewhat flattened ring, which otherwise shows no indications of dorsiventrality. The secretory canals in the phloem are strikingly large. Just below the point at which two opposite leaflets arise the rachis broadens out and the vascular ring becomes still more flattened. From each edge of the flattened ring a number of bundles bend out into the leaflet, the gaps in the vascular ring of the rachis thus produced closing up again at a slightly higher level.

(c) *The Connection between the Vascular System of Stem and Leaf.*

The relation between the vascular system of the stem and that of the leaf could only be determined in *Juliania adstringens*, of which a limited amount of spirit-material was available. The apex of the branches on which the clusters of leaves are borne is slightly flattened, which also finds expression in the outline of the vascular ring; the latter consists of a number of well-marked bundles separated by rather broad medullary rays. The stem at this point contains a superabundance of resin-canals in all parts of the ground-tissue, their number being especially striking in the pith. A little way below the insertion of a leaf the bundles situated on that side of the stem from which the leaf arises are found to approximate to one another, so that the intervening rays almost disappear. At a slightly higher level the almost compact plate of vascular tissue thus produced shows the first signs of a bulging out towards the outside, and this becomes more extensive as sections at progressively higher levels are examined; this protruded portion of the vascular system of the stem is ultimately cut off to supply the petiole. The rather considerable number of xylem-vessels found in these bundles in the stem becomes gradually distributed in a much thinner layer in the protruded portion (petiolar system). The latter at first merely looks like a little side-loop of the main vascular ring of the stem; at higher levels, however, it becomes very much expanded (and tangentially flattened) distally, while that part of it which lies next to the vascular system of the stem narrows down very considerably before joining up with the latter, so that the point of connection between the petiolar loop and the bundle-ring of the stem is rather a narrow one. Sections taken at a still higher level show the complete detachment of the petiolar

* Pringsheim's Jahrb. Bd. xxviii. 1895, pp. 227 *et seq.*

system and the closure of the gap in the vascular ring of the stem. The arrangement of the bundles in the detached petiolar system is very much like that found at the base of the petiole, the open upper end of the vascular arc corresponding in position to the gap in the axial vascular ring, but not being quite so pronounced as it is at a slightly higher level. Resin-canals seem to bend out into the petiole with the bundles.

The gap in the vascular ring of the stem caused by the emergence of the petiolar system is persistent even during the subsequent growth in thickness. In the young condition it is occupied by parenchymatous tissue, which has passed into it from the pith to take the place of the outgoing vascular tissue. In the older parts of the branch, some way behind the apex, these gaps in a transverse section appear as broad medullary rays composed of cells with somewhat thickened walls and bearing simple pits with a reticulate arrangement; these broad rays traverse a thick band of secondary wood, and are situated opposite the persistent leaf-bases, which, as will be remembered, are adnate for some little distance to the stem. The vascular system in these persistent leaf-bases also undergoes a certain amount of growth in thickness; successive sections through such a leaf-base enable one again to follow up the gradual bulging out of the petiolar system from the vascular ring of the stem and its final detachment. In the upper portion of the persistent leaf-base, however, the secondary wood and phloem of the vascular tissue form a complete ring.

(ii.) The Stem.

The structure of the stem is very constant in all the members of the Order, although distinguishing features are in some cases afforded by the distribution of the resin-canals. The common occurrence of isolated sclerenchymatous cells in the primary cortex is noteworthy as being the only indication in the vegetative organs of the plant of that tendency to form sclerenchyma which is so abundantly exhibited by the fruit.

The origin of the *cork* is apparently subepidermal, although it was not possible to determine this point with absolute certainty. The cells of the cork in most cases have relatively thin walls and are tabular in shape; the outer tangential walls are slightly arched outwards, whilst the radial walls are more or less undulated; in herbarium material the cells are commonly filled with tannin. In *Juliania glauca* the inner tangential walls are very considerably thickened. In longitudinal sections the cork-cells appear tabular and somewhat elongated.

In many cases a considerable number of the cells of the thin-walled parenchymatous *primary cortex* subsequently become more or less strongly thickened and sclerosed; this phenomenon is wanting only in *J. glauca*, where possibly the thickened cork-cells make up for the lack of sclerosis in the primary cortex. In the other species one frequently finds all stages from slightly thickened cortical cells with a wide lumen to stone-cells with a very small cavity. The thick walls of these cells are traversed by simple pits, which, however, sometimes appear to be bordered, owing to the dilatation of the pit-passage inside the substance of the wall. These thick-walled cells are all isodiametric or only very slightly elongated in the vertical direction. In *J. amplifolia* the entire inner portion of the primary cortex is composed of somewhat thickened and pitted

cells. Stone-cells are most markedly developed in *J. mollis.* Crystals generally occur in some quantity in the cells of the primary cortex; they are mainly clustered crystals, but solitary crystals are intermingled with them in small numbers.—Resin-canals are in all cases found in the primary cortex; they will be discussed more fully below.

The *secondary bast* always contains at least one ring of large secretory canals and a second ring of smaller ones may appear in the inner portion in the course of secondary growth. The canals of the main ring are each surrounded on the outer side by an arc of thick-walled tissue, which probably represents the remains of the primary bast, each arc corresponding to one of the original vascular bundles. The tissue in question consists of dead, more or less thickened cells, which are compressed by secondary growth, the walls being more or less undulated. In a longitudinal section it is difficult to make out the details accurately, but it is evident that the constituent cells are considerably elongated; probably most of this tissue (for which some German authors have created the special name "Hornbast") consists of obliterated sieve-tubes of the primary phloem. The way in which these arcs enclose the large resin-canals of the secondary bast is extremely characteristic and in every way recalls the appearance of a transverse section of the stem in the Anacardiaceæ.—For the rest, the secondary bast is characterised by the complete absence of bast-fibres. Clustered crystals generally occur abundantly in longitudinal rows of thin parenchymatous cells (chambered crystal-fibres), whilst solitary crystals are very rare; where they occur they are generally of rather large size. Within the mass of secondary bast one commonly meets with small groups of thick-walled tissue like those mentioned above as forming an arc round the larger resin-canals.

The structure of the *wood* is very uniform in all the Julianiaceæ. The medullary rays are mostly only one, more rarely two cells in breadth, but never broader; in a transverse section the cells are oblong and more or less elongated in the radial direction; in a radial longitudinal section they are rectangular, the long axis either being placed radially or vertically (horizontal or upright medullary ray cells). The walls are somewhat thickened and provided with simple pits; the cells occasionally contain solitary crystals. Wood-parenchyma is almost entirely wanting in the secondary wood, but occurs in small quantity round about the primary vessels. The ground-mass of the wood is constituted by thick-walled wood-prosenchyma, the walls of which are provided with irregularly arranged slit-shaped simple pits; these elements are very commonly septate by means of thin partition-walls. The vessels are rather numerous (particularly so in *Orthopterygium*) and are irregularly disposed in a transverse section; they are mostly isolated, but are sometimes found in groups of two or three together. They have lumina of medium size (maximum diameter = 65–70 μ) and their shape is more or less circular. The perforations of the vessels are most commonly simple, although a few scalariform perforations are to be met with; in contact with the cells of the medullary rays the vessels bear large reticulately arranged simple pits on their walls, while other parts of the wall are provided with large simple or bordered pits. Spiral thickening does not occur in the secondary wood.

The well-developed *pith* is made up of slightly thickened circular cells of varying size, the walls of which bear simple pits. In a longitudinal section the cells are rectangular

in shape, being elongated in the vertical direction. Many of the cells are commonly filled with numbers of discoid starch-grains, and small clustered crystals occur in minor numbers. In three of the five species (exceptions: *Juliania adstringens, Orthopterygium Huaucui*) a considerable number of small resin-canals are found in the pith.

It still remains to describe the *secretory canals* occurring in the various parts of the stem. The largest are those forming the main ring in the secondary bast; these, though evidently schizogenous in the first place, ultimately become lysigenous like the large resin-canals in the bast of the petiole. The smaller canals occurring in the later-formed portions of the secondary bast and in the primary cortex are, however, generally purely schizogenous. The resin-canals of the primary cortex vary very much in size, and are usually more or less irregularly arranged. Those of the pith are very small, and mostly only consist of the secretory cavity, surrounded by a single layer of thin-walled parenchymatous cells (fig. 2, C, p. 138); they are quite irregularly distributed in the medullary tissue.

(iii.) The Female Inflorescence. (See Plate 20.)

The complicated structure of the female inflorescence (*cf.* Hemsley, p. 182) can only be fully understood by the examination of a series of microtome-sections; these show how the system of collaterally-arranged cavities, occurring in the inflorescence and ripe fruit, originates. I propose in the following lines to briefly describe such a series of sections with the help of the diagrams shown on Plate 20. It should be mentioned at the outset that the entire involucre, with its contained flowers or fruits, is generally seated obliquely on the winged peduncle, so that transverse sections of the inflorescence cut the individual flowers at different levels.

Fig. A is a diagram of a section which has passed through the upper region of the inflorescence. The involucre (*i.*) is seen as an envelope, which is incomplete on the one side—a result of the general obliquity of the inflorescence referred to above. Within the involucre we meet with the styles of three distinct flowers (*ov.* 1, *ov.* 2, *ov.* 4; shaded by lining and dotting in this diagram), the style of the fourth flower, which was altogether very slightly developed in this inflorescence, not lying within the level of the section A. *ov.* 1 and *ov.* 2 are the styles of the two large median flowers of the inflorescence, and were the only ones which projected from the top of the involucre; one of the styles (*ov.* 2) is considerably larger than the other and also projected to a much greater extent than *ov.* 1. The third style (*ov.* 4) belongs to the one smaller lateral flower and did not project beyond the apex of the involucre at all. At the level of the section A one style (*ov.* 2) is already beginning to fuse with the involucre on one side. If we examine sections from successively lower levels we gradually find *ov.* 2 also fusing with the involucre on the other side, and at the same time *ov.* 1 commences to join up with the wall of the involucre; at a slightly deeper level *ov.* 4 also fuses with the investment of the inflorescence. Within the involucre, which is now complete all round, we then (fig. B) have three cavities lying side by side (*s.* 1, *s.* 2, *s.* 3), which are separated from one another by masses of tissue (*ov.* 1, *ov.* 2, *ov.* 4) due to the lateral fusion of the three ovaries with the wall of the involucre. At a somewhat deeper level

(fig. B) we find cavities beginning to appear in the masses of tissue *ov.* 2 and *ov.* 4; these cavities are the ovarial cavities of one median and one lateral flower, and, as will be seen by a glance at the diagram, they are almost filled by the contained ovule (dotted). Lower down in the series the cavity *ov.* 2 gradually enlarges (fig. C), whilst *ov.* 4, which belongs to a small lateral flower, commences to disappear again; at the same time an ovary begins to appear in *ov.* 1. When *ov.* 4 is almost on the point of disappearing, another ovary appears on the opposite side (*ov.* 3, see fig. C); this belongs to the other small lateral flower, and in the case examined contained no ovule whatsoever. These small lateral flowers of the inflorescence, since their style and stigmas remain concealed within the involucre, probably stand little chance of being fertilised, and are as good as abortive. In fig. D *ov.* 4 has entirely disappeared, while the two median flowers show well-developed elongated ovarial cavities with large ovules; *ov.* 3 disappears in the next figure (fig. E), the flower to which it belongs being a very small one (occurs only in figs. C & D). Of the two median flowers, the first to appear (*ov.* 2) is also the first to disappear (*cf.* fig. F); sections taken very low down in the inflorescence show only the ovary *ov.* 1 (fig. G) of all the many cavities occurring in the upper part. Fig. H shows the base of the inflorescence (the expanded upper portion of the peduncle), in which no trace of the cavities remains.

It will be noticed that the bases of the individual flowers are completely embedded in the tissue of the involucre (fig. F), and that the cavities separating them laterally from one another only appear somewhat higher up (fig. E). Another noticeable point is the way in which in some of the sections (figs. E, F) the ovules contained in the ovaries appear in two halves; this is due to the curious shape of the ovule *. Near one end of the ovule many of the sections (figs. C, D, E) show a small mass of cells with densely granular contents; this possibly marks the position of the embryo †.

The tissue of the involucre at this stage consists of thin-walled parenchymatous cells, traversed by numerous resin-canals (*r* in the figures), which are rounded in transverse section, and most of which possess a single epithelial layer. A few xylem-elements (in some cases also a little phloem) generally occur in relation to the secretory canals, but there is not much vascular tissue in the inflorescence at this stage. The walls of the ovaries of the individual flowers are purely parenchymatous, and prior to or just after fertilisation appear to contain neither vascular tissue nor resin-canals, though both appear subsequently (*cf.* below). Scattered about in the involucre are cells with walls which are slightly thicker than those of the majority, and recalling the thickened cells in the cortex of the stem. The epidermis of the involucre consists of cubical cells and bears a considerable number of clothing and glandular hairs.

(iv.) The Fruit. (Plate 21.)

The anatomy of the ripe fruit of the Julianiaceæ shows a great degree of complexity; it could only be examined in the genus *Juliania*, since only quite young fruits of *Orthopterygium* were obtainable. As above explained, the four individual flowers of the female inflorescence are, except for the styles of two of them, completely enclosed by

* Hemsley, pp. 182 *et seq.*

† Hemsley, p. 188 (*cf.* fig. 22).

the involucre; the latter increases very considerably in size in the fruit, and at the same time its cells become thickened in various ways, so that the resulting investment is very tough and hard. Each of the flattened ovaries, representing as many flowers, and, as will be remembered, adnate to the involucre by their narrow edge along the greater part of their length, has relatively thin walls; the latter are, however, of a very hard consistency, owing to the occurrence of numerous longitudinal strands of thick-walled sclerenchyma in them (Pl. 21. figs. 1 & 2). The strands give the walls a characteristic dotted appearance in transverse section, and form the numerous anastomosing ribs on the flat sides of the individual ovaries.

The structure of the *young fruit,* which was examined in *Juliania amplifolia* (Rose and Hough, 4819), is very different from that of the mature one. Its tissues are made up of cells with relatively thin walls, and contain no sclerenchymatous elements whatever; numerous large resin-canals are present, the contents of which are a much clearer yellow than in the canals of the vegetative organs. In many points, however, the future structure is already indicated. The outer surfaces of the individual ovaries at this stage bear numerous multicellular hairs like those occurring on the vegetative organs (Pl. 21. fig. 5, *h.*); the hairs are mostly present in such numbers as to completely bridge over the space between two contiguous ovaries. The walls of the ovaries are thin in the median region, but broaden considerably as we approach the ends, which are connected with the involucre. The external layer of the ovary-wall, bearing the above-mentioned hairs, consists of cells which have thin walls and are frequently already at this stage considerably compressed, and hence difficult to distinguish; internal to this layer are several layers of thin parenchymatous cells, in which the large resin-canals are situated externally, while a limited number of vascular bundles traverse them internally; these bundles run in the transverse plane (Pl. 21. fig. 5, *v.b.*). The inner lining of the ovary-wall is separated from the general tissue of the wall (*i. e.* that containing the resin-canals and vascular strands) by a very characteristic layer of large cells containing solitary crystals (Pl. 21. fig. 5, *c.l.* 1). These cells are plano-convex in shape in a transverse section, their convex surface being more strongly thickened and facing towards the cavity of the ovary. This layer, as will be seen below, is also very easy to recognise in the mature fruit, although the crystals contained in it are then of a much larger size. The inner limit of the ovary-wall (Pl. 21. fig. 5, *i.ep.*) is constituted by a layer of cells with slightly thickened walls, and varying very much in size and shape; at some points these cells form a single layer, but, as a rule, there are two cells in front of one another. In surface-view these cells have a more or less undulated outline. Towards the narrow edge of the ovary, where the latter merges into the wall of the involucre, these cells attain a much more extensive development and form a large number of layers; at the same time the walls become less strongly thickened, while many of the cells are drawn out in various directions, and so become much contorted. At these points, therefore, the inner limit of the ovary-wall, instead of being formed by a definite layer, consists of an irregular mass of cells; numerous relatively small solitary crystals occur throughout this tissue, being only absent from the innermost cells bordering on the ovarial cavity; the latter have somewhat thicker walls, and tend to assume an

isodiametric shape, so that they constitute a kind of inner epidermis. The wall of the involucre has very much the same structure as the outer portion of the ovary-walls, being composed of thin-walled parenchymatous tissue traversed by resin-canals and vascular strands. The outermost layers are brown in colour and contain numerous clustered crystals of medium size; hairs occur sparingly on the outer surface of the involucre.

The structure of the *mature fruit* is far more complicated, but is very nearly uniform in all the cases investigated; so it seems advisable to first describe the anatomy for one species and then to mention the points of difference presented by the others. A transverse section through one of the walls of the original ovaries in the ripe fruit of *J. amplifolia* (Rose, 3735) or *J. adstringens* (Pl. 21. figs. 1 & 2) shows the following structure:—The cavity of the ovary, which contains a single seed, is lined by a layer of cells, which are cubical to rounded or of irregular shape in transverse section, and have very strongly thickened and often distinctly stratified walls (Pl. 21. figs. 1 & 2, *i.ep.*). In most cases the thickening goes so far that only a small dot-like lumen remains, from which very fine canals frequently radiate outwards. These cells have a thin cuticle and form a perfectly continuous and smooth layer lining the cavity of the ovary internally. In surface-view (Pl. 21. fig. 3, *i.ep.*) the cells are seen to have a more or less undulating outline, and the way in which the lumen commonly radiates out into the thickening layers of the walls is readily seen. Both in general shape and position these cells agree with those forming the inner limit of the wall of the ovarial cavity in the young fruit (*cf.* above), and they undoubtedly arise from the latter by the apposition of thickening-layers to the original cell-wall. Immediately external to this inner lining layer we meet with the same characteristic crystal-containing cells as in the young fruit (Pl. 21. figs. 1 & 2, *c.l.* 1); these cells generally still have a more or less plano-convex shape, but some have become rounded or ellipsoidal in transverse section. Their walls are considerably thickened and provided with a small number of simple pits; a well-developed lumen remains, however, and this is practically filled out by a large solitary crystal of oxalate of lime. In a surface-view of the ovary-wall these cells appear very large and rounded (Pl. 21. fig. 3, *c.l.* 1), the crystals contained in their lumen often having rather an irregular shape. These cells, with their large crystals, form a very pronounced although interrupted line immediately beneath the inner epidermis of the ovary-wall; they absolutely correspond to the layer occupying the same position in the young fruit. The remaining structure of the ripe fruit is not so easily correlated with that of the young one. The line of subepidermal crystal-containing cells is not continuous, but is interrupted by occasional small cells (Pl. 21. fig. 1) without crystalline contents and having only a very small dot-like lumen. These cells really belong to the mass of tissue lying external to the crystalline layer; this tissue (Pl. 21. figs. 1 & 2, *m.*) consists of several layers of thick-walled cells, and has developed in the position formerly occupied by the thin parenchyma, traversed by the vascular bundles; of the latter no traces are to be found in the mature fruit. The cells of the tissue in question are fairly large and have strongly thickened more or less distinctly stratified walls, the thickening being so extensive that the cavity of the cell is in most cases

reduced to a mere point or is flatly compressed so as to appear as little more than a line. The cells themselves vary exceedingly in shape, being contorted and compressed and elongated in various directions. Isolated solitary crystals often occur in this tissue (Pl. 21. fig. 1).

Immediately beneath the outer bounding layers of the fruit-wall a number of thick round bundles of sclerenchymatous fibres are situated (Pl. 21. figs. 1 & 2, *scl.*), the individual fibres being much elongated in the longitudinal direction and having a polygonal outline and a distinct rounded lumen in transverse section; the walls of the fibres are thick and of a white colour. In a surface-view of the ovarial wall these bundles are seen to branch frequently, the branches anastomosing with one another and forming the complicated network of ribs visible on the outer walls of the ovaries. These bundles of sclerenchymatous fibres, of which there is no indication whatever in the young fruit, develop in the outer portion of the thin parenchymatous tissue, which contained the abundant resin-canals; the latter are no longer recognisable in the mature fruit. It seems as if the sclerenchymatous strands first commence to develop round about these resin-canals, gradually encroaching more and more upon them, until ultimately they are entirely obliterated. In the middle of the bundles of sclerenchyma one frequently meets with a small mass of brown disorganised tissue, which possibly represents the remains of the secretory organs in question. Between these sclerenchymatous strands and separating them laterally from one another are masses of large and relatively thin-walled cells with abundant simple pits on their walls (Pl. 21. fig. 1, *p.*); these pits are often developed to such an extent as to give rise to a kind of reticulate or scalariform appearance on the wall. In a transverse section of the ovary-wall these cells appear the more elongated the nearer they lie to the sclerenchyma-bundles, those immediately bordering on the latter being quite like fibres and arching round the bundle, till at the middle point of the internal surface of the latter they bend inwards and form part of the bundle (Pl. 21. fig. 1, *f.*). These bundles of sclerenchyma and the intervening large pitted cells are separated from the more internal tissues of the ovary-wall by a layer of large cells containing large solitary crystals. This crystalline layer (Pl. 21. fig. 1, *c.l.* 2) quite resembles that occurring beneath the inner lining-layer of the wall, but has an undulated course; it is bent outwards between each pair of sclerenchymatous bundles. In many cases all the tissues internal to the bundles of sclerenchyma have their cell-walls coloured a bright yellow.

The large, simply pitted cells lying between the bundles of fibres acquire gradually thinner walls as the outside is approached (*cf.* especially Pl. 21. fig. 2). I have already mentioned that the sclerenchymatous bundles branch and anastomose in a highly characteristic manner, the meshes, formed by their network, being occupied by the thinner pitted cells (*p.*). The outer lining-layer of the ovary-wall at this stage is formed by a mass of brown compressed tissue, in which the individual cells are no longer recognisable (Pl. 21. figs. 1 & 2, *o.ep.*). At many points this layer is even completely wanting, the outer surface of the ovary-wall being formed by the sclerenchymatous bundles and the intervening pitted cells (*cf.* Pl. 21. fig. 1). In some cases a few hairs are still to be met with on the outer surface of the ovary (Pl. 21. fig. 2).

At the base of each individual ovary the numerous sclerenchyma-bundles traversing its walls bend in and become approximately horizontal in their course, thus forming a compact sclerenchymatous base in which the four individual fruits are inserted basally. These bundles all run in the horizontal plane, but otherwise their direction within that plane varies; a longitudinal section consequently cuts some of them longitudinally, others transversely, and others again obliquely, so that the appearance is a very complicated one.

The main mass of the *involucre* at this stage consists of a spongy white tissue, which is made up of large thin-walled cells of varying shape and having abundant simple pits on their walls, the latter often giving rise to a reticulate appearance (Pl. 21. fig. 4). These cells, which are mostly rounded or oblong in shape, occasionally contain a solitary or clustered crystal; here and there a resin-canal is still to be found more or less preserved in the midst of this tissue. Towards the outer limit of the involucre the cells become somewhat smaller and have thicker walls, while at the same time they exhibit tangential flattening; the outermost layer has a thick dark brown cuticle. A few small bundles of sclerenchyma, quite like those occurring in the ovary-walls, lie scattered beneath the outermost cell-layers of the involucre.

The flattened winged *peduncle* of the entire fruit is made up of the same kind of thin-walled cells as the main mass of the involucre; the walls are provided with considerable numbers of variously shaped simple pits. Beneath the outer surface of the peduncle a number of sclerenchymatous bundles are situated; the component cells, however, have considerably thinner walls than is the case with the sclerenchyma in the fruit itself. At the inner limit of these bundles a few vessels generally lie, although I have not been able to make out any phloem. The outermost layers of the wing, as in the involucre, consist of a few layers of much compressed cells with brown walls.

The main structural features above described exhibit very little variation. In some cases the outer crystal-containing layer in the ovary-wall is suppressed, and the tissue on its inner side is only developed to a slight extent, so that the inner crystalline layer comes to lie very close to the bundles of sclerenchyma (Pl. 21. fig. 2); this phenomenon is found in one and the same species, sometimes even in different parts of the same fruit. In some cases it may possibly be only a stage in the development of the mature fruit. The outer crystal-containing layer does not always form the absolute outer limit of the thick-walled tissue *m* (in Pl. 21. fig. 1), for a few cells of the latter may also occur on its outer side (Pl. 21. fig. 1). Another feature varying within certain limits is to be found in the thickness of the walls of the large cells which form groups separating the sclerenchyma-bundles from one another laterally. Figs. 1 & 2 on Plate 21, which are both from different specimens of the same species, illustrate this variation sufficiently well. The same two figures also show that the inner lining of the ovary-wall may be formed by one or two layers of cells.—Owing to the rather considerable variations in the minor features, it is impossible to base any specific differences on the internal structure of the fruit. That of *Juliania glauca* agrees with the above description in all essential respects.

As above mentioned, only young fruits of *Orthopterygium Huaucui* were available.

Their investigation has revealed certain peculiarities, which may be due to their immature condition, though possibly they may mean distinct characters. The sclerenchyma-bundles are just as characteristically developed, but the tissue internal to them did not show nearly so great a thickening of its walls. The crystalline layers are very indistinct—entirely absent in some places.

(v.) The Embryo.

Satisfactory material of the embryo was only obtained in *Juliania adstringens* (Nelson, n. 1827). The hypocotyl, as seen in a transverse section through the fruit, is triangular with rounded angles. It contains four rudimentary vascular bundles, which at this stage contained no lignified elements whatever. In the phloem-portion of each bundle a single resin-canal is already developed, the secretory cavity being lined by a layer of elongated cells. This early development of the resin-canals is noteworthy, and shows that the plant commences to exercise its secretory function even before the ordinary conducting elements are fully differentiated. The ground-tissue of the hypocotyl is made up of rounded cells with thin walls. The epidermal cells are small.

The main mass of the cotyledons is composed of elongated palisade-cells, surrounded by an epidermis of small cubical cells. All the cells are densely crowded with starch-grains.

(vi.) Anatomical Diagnosis of the Order.

The following are the chief points of agreement exhibited by the different members of the Julianiaceæ:—

(i.) *Leaves* more or less typically bifacial, the tissues often showing a distinct stratification; no hypoderm; palisade-tissue a single layer of much elongated narrow cells.

(ii.) Epidermis of the leaf often with a striated cuticle; stomata almost invariably confined to the lower epidermis, without subsidiary cells.

(iii.) Simple uniseriate clothing-hairs of a slightly varying type; glandular hairs with a short stalk and a more or less club-shaped glandular portion.

(iv.) Vascular bundles of the leaf with little xylem and no accompanying sclerenchyma; a resin-canal in the bast of each bundle.

(v.) Oxalate of lime only in the form of clustered crystals in the leaf.

(vi.) *Petiole* at its base with a ring of bundles open on the upper side; at its apex with a complete ring.

(vii.) In the *stem* cork-development probably subepidermal; cortex commonly with scattered thickened and sclerosed cells.

(viii.) Resin-canals in the secondary bast enveloped externally by arc-shaped groups of obliterated phloem.

(ix.) Wood with narrow medullary rays, the cells of which bear simple pits; wood-parenchyma practically absent; wood-prosenchyma with slit-shaped simple pits, often septate; vessels rather numerous, for the most part with simple perforations; their walls bear large simple pits when in contact with elements of the medullary rays, while at other points there are simple or bordered pits.

(x.) Pith composed of spherical cells with simple pits.

(xi.) *Resin-canals* present in the phloem throughout all parts of the plant; also in some cases in the cortex and pith of the petiole and in the pith of the stem; always present in the cortex of the stem. Development schizolysigenous; present in the embryo.

(xii.) *Fruit* with longitudinal bundles of sclerenchyma traversing the pericarp and showing very definite layers of cells containing solitary crystals (except in *Orthopterygium* ?).

The anatomical diagnosis of the two genera is as follows:—

1. *Juliania*, Schlecht.—Cuticle of foliar epidermis usually striated; clothing-hairs usually of more than two (5–10) cells, long, pointed, with a swollen base, and restricted to the veins; glandular hairs fairly long with a well-marked stalk and a head with prevalent horizontal division; palisade-cells with straight walls, all the cells of equal size; cortical resin-canals in the petiole (?); resin-canals generally present in the pith of the stem (except *J. adstringens*).

2. *Orthopterygium*, Hemsl.—Cuticle of foliar epidermis smooth; clothing-hairs generally bicellular, rather short, not very pointed, without much swelling basally, and distributed fairly uniformly over the leaf-surface; glandular hairs short, somewhat globular in shape, with a short unicellular stalk and a head with numerous horizontal and vertical division-walls; palisade-cells with finely undulated walls, cells of two sizes; tracheids in the smaller veins of the leaf with enlarged terminations; no cortical resin-canals in the petiole (?); no medullary resin-canals in the stem.

The anatomical diagnoses of the species are as follows:—

Juliania adstringens, Schlecht.

(Pringle, n. 7243; Nelson, n. 1827; Rose & Hay, n. 5341; Langlassé, n. 319 bis.)

Cuticle of upp. and low. epid. not very distinctly striated; stom. occur sparingly also on upp. epid.; hairs on mature leaf very long and much convoluted, composed of 4–5 cells, sometimes unicellular; glands with a short stalk and ovoid head; lowest layer of spongy tissue tends to develop as palisade; clust. cryst. of leaf in particularly large idioblasts; no medullary resin-canals in the stem.

Juliania mollis, Hemsl.

(Pringle, n. 6871.)

Cuticle of upp. epid. distinctly striated, that of low. epid. scarcely striated; hairs abundant, esp. on low. epid., mostly long, straight, pointed, and often composed of 10 or more cells; glands tend to be much elongated, gland. portion of numerous short cells having almost same diam. as stalk, which is made up of 1–2 much elongated cells; lowest layer of spongy tissue tends to develop as palisade; stone-cells markedly developed in cortex of stem; medullary resin-canals in the stem.

Juliania amplifolia, Hemsl.

(Rose & Hough, nn. 3735, 4755, 4819.)

Cuticle of both epid. distinctly striated; hairs like those of *J. mollis*, but often bent and with a smaller number of cells; glands with a fairly long unicellular stalk and

an oval, elongated head, which is often not much broader than the stalk; clust. cryst. of leaf in particularly large idioblasts; entire inner portion of prim. cortex of stem composed of somewhat thickened cells; resin-canals in the pith of the stem.

Juliania glauca, Hemsl. & Rose.
(Without any number.)

Cuticle of both epid. (esp. the lower) very strongly striated; stom. long and narrow; hairs absent or very rare; glands rather like those of *J. adstringens*; inner tangential walls of cork-cells very considerably thickened; no thickened and sclerosed cells in the primary cortex of the stem; resin-canals in the pith of the stem.

Orthopterygium Huaucui, Hemsl.
(Without any number.)

See the generic diagnosis above (p. 150).

EXPLANATION OF THE PLATES.

Plate 20.
(Structure of the inflorescence.)

Description in text, pp. 143, 144. Fig. A is inverted with reference to the remaining figures. *i.*=involucre; *ov.* 1, *ov.* 2, *ov.* 3, *ov.* 4, styles and ovaries of the four individual flowers of the inflorescence (shaded by lines aud dots); *s.* 1, *s.* 2, *s.* 3, the spaces separating the flowers laterally; *r.*=resin-canals.

Plate 21.

Anatomy of the fruit of Juliania:—*i.ep.* = inner epidermis of ovary-wall; *o.ep.* = outer ditto; *c.l.* 1 = inner layer of crystal-containing cells; *c.l.* 2 = outer ditto; *m.* = thick-walled tissue between the two layers; *scl.* = sclerenchyma-bundles; *f.* = cells, which at the inner limit of the bundles bend in and form part of them; *p.* = thick-walled pitted tissue between the bundles; *t.* = thin-walled tissue beneath *o.ep.*; *h.* = hair; *hb.* = hair-base.

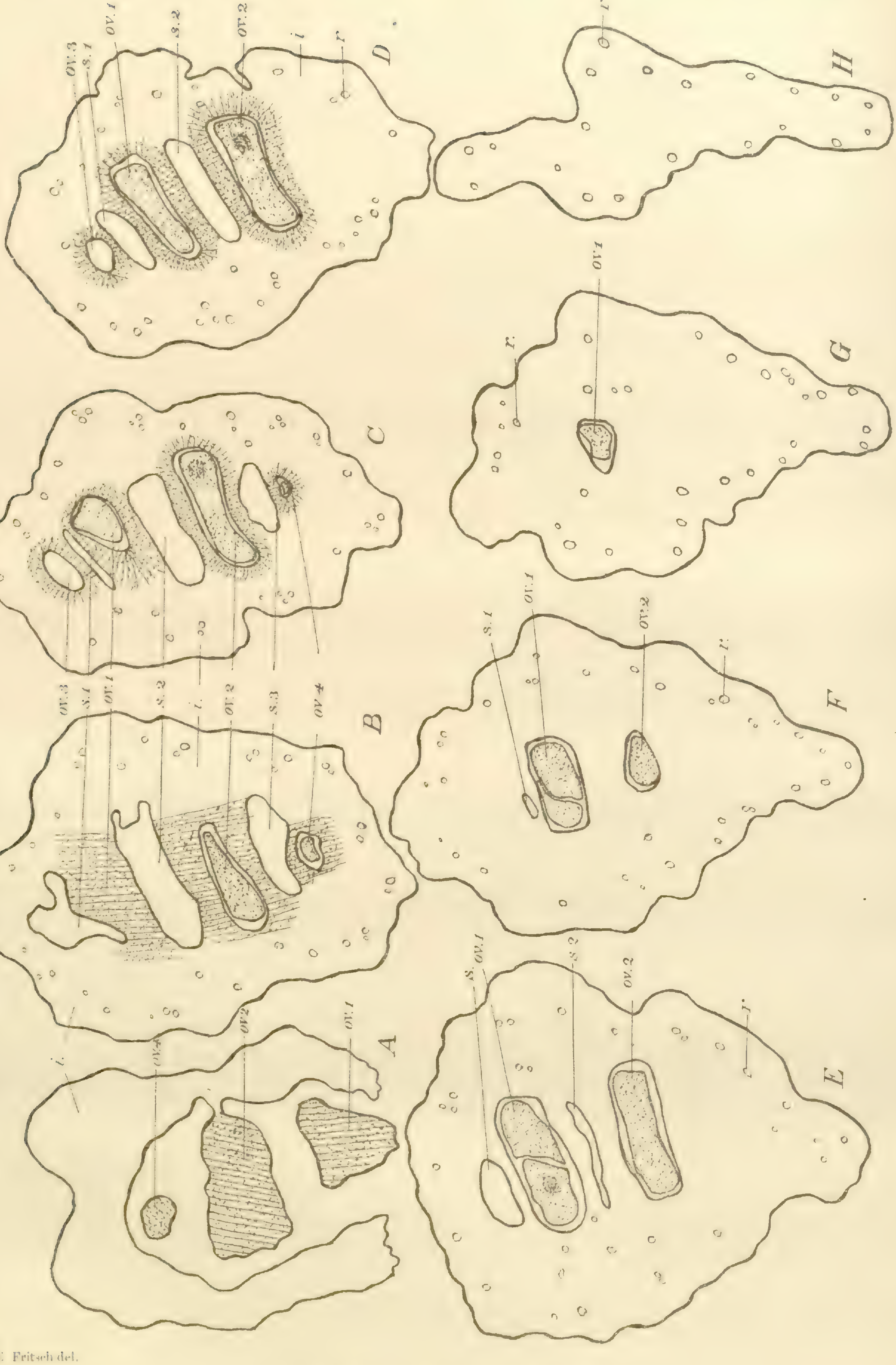
Fig. 1. *Juliania adstringens* (Langlassé, n. 319 bis), transverse section through ovary-wall in the ripe fruit; the outer integumental tissues (*o.ep.*) are to a great extent wanting. (× 120.)

Fig. 2. *J. adstringens* (Nelson, n. 1827), transverse section through an ovary-wall, in which the outer crystalline layer is absent. (× 205.)

Fig. 3. *J. amplifolia* (Rose, n. 3735), surface-section of the inner surface of the ovary-wall, showing the inner epidermis and the crystal-containing layer beneath it. (× 320.)

Fig. 4. *J. adstringens* (Langlassé, n. 319 bis), thin-walled pitted cells from wall of involucre. (× 215.)

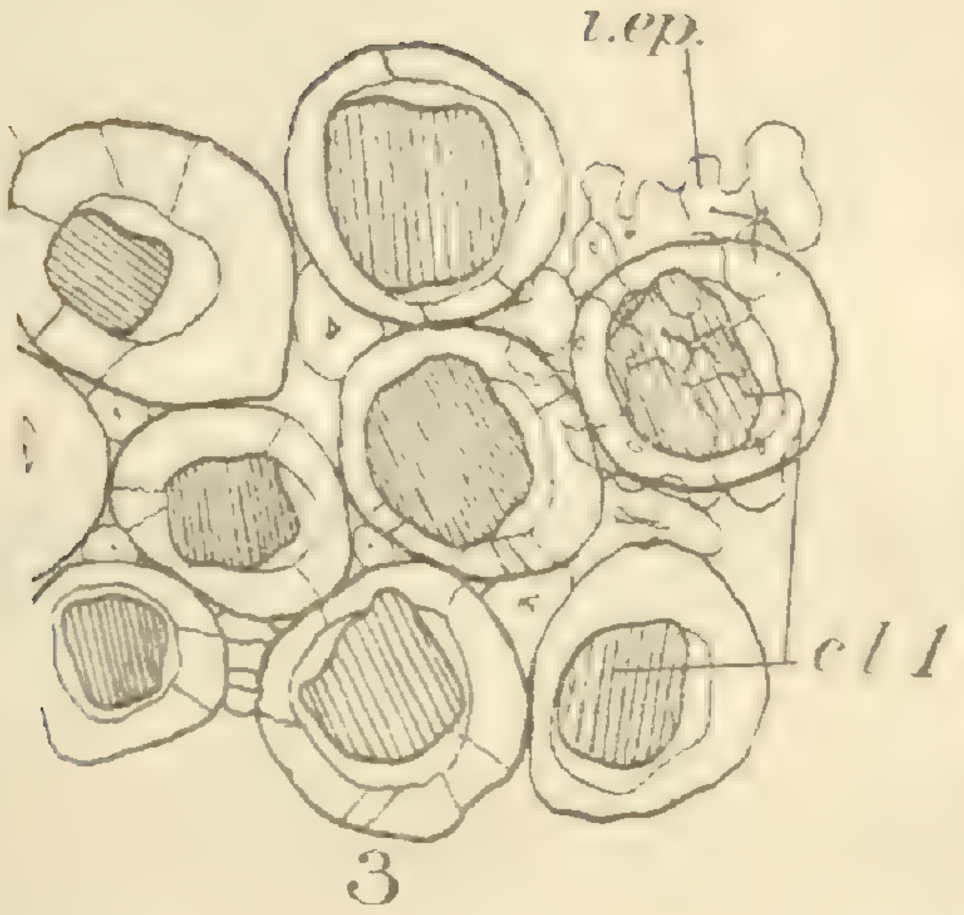
Fig. 5. *J. amplifolia* (Rose & Hough, n. 4819), transverse section through ovary-wall in young fruit; *v.b.* = vascular bundles, *r.c.* = resin-canals. (× 120.)



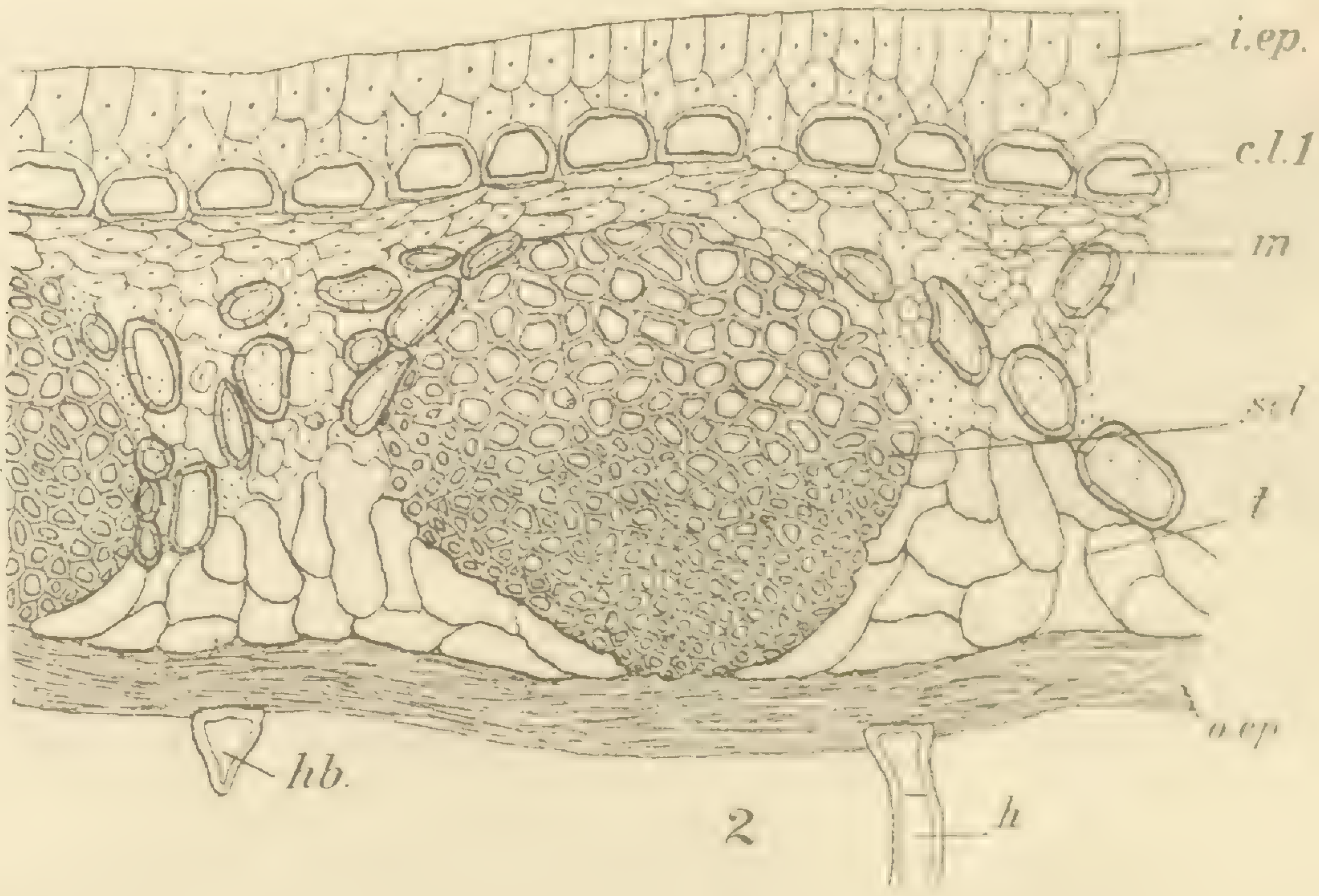
F. E. Fritsch del.

ANATOMY OF JULIANIACEÆ.

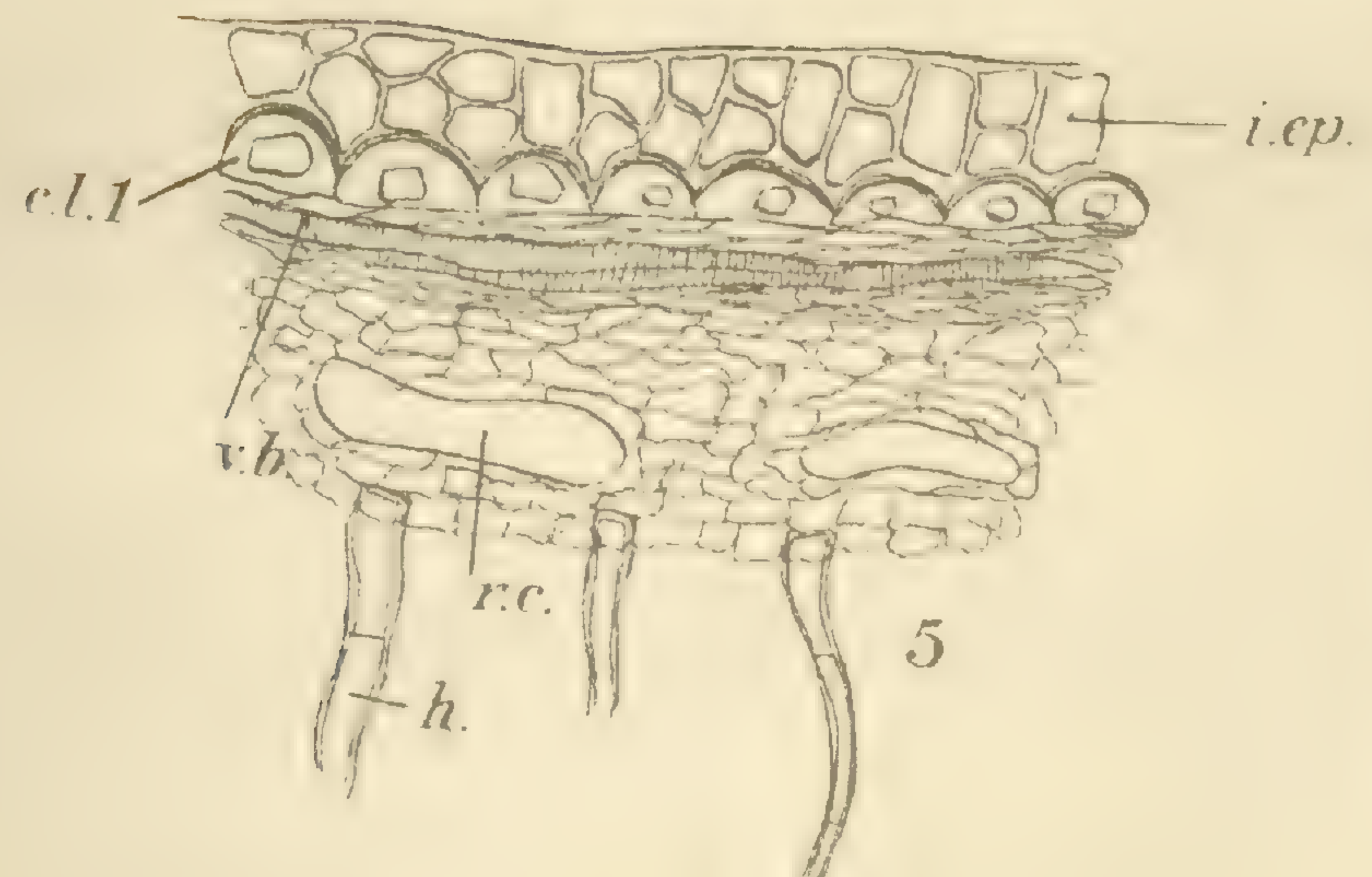
1



3



2



5

4

F. E. Fritsch del.

ANATOMY OF JULIANIACEÆ.

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s.* to the public, and 6*s.* to Fellows; to Vols. 26–30, 4*s.* to the public, and 3*s.* to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

SECOND SERIES.—BOTANY.

Volume.		When Published.	Price to the Public. £	*s.*	*d.*	Price to Fellows. £	*s.*	*d.*
I.	Part	I. 1875.	0	8	0	0	6	0
	Part	II. 1875.	0	16	0	0	12	0
	Part	III. 1876.	0	12	0	0	9	0
	Part	IV. 1876.	0	10	0	0	7	6
	Part	V. 1878.	1	4	0	0	18	0
	Part	VI. 1879.	1	6	0	0	19	6
	Part	VII. 1880.	1	4	0	0	18	0
	Part	VIII. 1880.	1	1	0	0	16	0
	Part	IX. 1880.	1	0	0	0	15	0
II.	Part	I. 1881.	0	12	0	0	9	0
	Part	II. 1882.	0	5	0	0	3	9
	Part	III. 1883.	0	10	0	0	7	6
	Part	IV. 1883.	0	3	0	0	2	3
	Part	V. 1883.	0	3	0	0	2	3
	Part	VI. 1884.	0	13	6	0	10	0
	Part	VII. 1884.	0	9	6	0	7	0
	Part	VIII. 1884.	0	10	0	0	7	6
	Part	IX. 1886.	0	7	0	0	5	0
	Part	X. 1887.	0	3	4	0	2	6
	Part	XI. 1886.	0	6	0	0	4	6
	Part	XII. 1886.	0	8	0	0	6	0
	Part	XIII. 1887.	1	7	0	1	0	0
	Part	XIV. 1887.	0	7	0	0	5	0
	Part	XV. 1887.	0	10	0	0	7	6
	Part	XVI. 1888.	0	2	6	0	2	0
III.	Part	I. 1888.	3	12	0	2	14	0
	Part	II. 1891.	0	5	0	0	3	9
	Part	III. 1891.	0	7	0	0	5	0
	Part	IV. 1891.	0	6	0	0	4	6
	Part	V. 1891.	0	6	0	0	4	6
	Part	VI. 1891.	0	3	6	0	2	8
	Part	VII. 1892.	0	6	0	0	4	6
	Part	VIII. 1893.	0	6	0	0	4	6
	Part	IX. 1893.	1	8	0	1	1	0
	Part	X. 1894.	0	10	0	0	7	6
	Part	XI. 1894.	0	3	4	0	2	6

SECOND SERIES.—BOTANY (*continued*).

Volume.		When Published.	Price to the Public. £	*s.*	*d.*	Price to Fellows. £	*s.*	*d.*
IV.	Part	I. 1894.	1	0	0	0	15	0
	Part	II. 1894.	2	0	0	1	10	0
	Part	III. 1895.	2	10	0	1	17	6
	Part	IV. 1895.	0	3	4	0	2	6
V.	Part	I. 1895.	0	9	0	0	6	9
	Part	II. 1895.	0	12	0	0	9	0
	Part	III. 1896.	0	6	0	0	4	6
	Part	IV. 1896.	1	0	0	0	15	0
	Part	V. 1896.	0	14	0	0	10	6
	Part	VI. 1896.	0	4	0	0	3	0
	Part	VII. 1897.	0	4	0	0	3	0
	Part	VIII. 1897.	0	6	0	0	4	6
	Part	IX. 1899.	0	12	0	0	9	0
	Part	X. 1899.	0	6	0	0	4	6
	Part	XI. 1899.	0	7	0	0	5	0
	Part	XII. 1899.	0	12	0	0	9	0
	Part	XIII. 1900.	0	1	6	0	1	2
	Part	XIV. 1900.	0	3	0	0	2	3
	Part	XV. 1901.	0	6	0	0	4	6
VI.	Part	I. 1901.	1	10	0	1	2	6
	Part	II. 1901.	0	6	0	0	4	6
	Part	III. 1902.	0	18	0	0	13	6
	Part	IV. 1903.	0	8	0	0	6	0
	Part	V. 1903.	0	8	0	0	6	0
	Part	VI. 1903.	0	12	0	0	9	0
	Part	VII. 1904.	0	12	0	0	9	0
	Part	VIII. 1904.	0	12	0	0	9	0
	Part	IX. 1904.	0	7	0	0	5	3
	Part	X. 1904.	0	14	0	0	10	6
	Part	XI. 1905.	0	4	0	0	3	0
VII.	Part	I. 1904.	0	5	0	0	3	9
	Part	II. 1905.	0	6	0	0	4	6
	Part	III. 1906.	0	3	0	0	2	3
	Part	IV. 1906.	0	7	0	0	5	3
	Part	V. 1907.	0	10	0	0	7	6
	Part	VI. 1907.	0	4	0	0	3	0
	Part	VII. 1907.	0	6	0	0	4	6
	Part	VIII. 1908.	0	5	0	0	[illegible]	9

2nd Ser. BOTANY.] [VOL. VII. PART 9.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

ON THE ORIGIN OF DI-TRIMEROUS WHORLS AMONG THE FLOWERS OF DICOTYLEDONS.

BY

THE REV. PROF. G. HENSLOW, M.A., F.L.S., F.G.S.

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

January 1908.

IX. *On the Origin of Di-trimerous Whorls among the Flowers of Dicotyledons.*

By the Rev. Prof. G. Henslow, *M.A., F.L.S., F.G.S.*

(With two Text-figures.)

Read 7th November, 1907.

In some papers on Phyllotaxis and Æstivations *, I have explained the origin of the quinary or $\frac{2}{5}$ arrangement—or "angular divergence" as it is called—from opposite and decussate leaves, originating with the two cotyledons, and giving rise to whorls of fives in flowers of Dicotyledons. When this change occurs from opposite to alternate arrangements in the leaves—as may readily be seen in stems of the Jerusalem Artichoke and Epilobiums,—the $\frac{2}{5}$ necessarily follows, the divergences $\frac{1}{2}$ and $\frac{1}{3}$ not being obtainable in this way.

The origin of the di- and tri-trimerous whorls among Dicotyledons, therefore, must be explained in a different manner from that of the simply trimerous whorls of Monocotyledons. The former are derived from single cycles of the $\frac{2}{5}$ and $\frac{3}{8}$ arrangements respectively; while the latter consist of successive single cycles of the $\frac{1}{3}$. This divergence is possible in Dicotyledons, but rare.

Of the several orders usually placed at the beginning of Floras, some, as Ranunculaceæ, Dilleniaceæ, Calycanthaceæ, and Nymphæaceæ, have chiefly quinary flowers; others have ternary whorls throughout, or else partly so, especially of the calyx and corolla. These orders are often characterized by indefinite stamens and carpels, all being free. This is a condition favouring the production of ternary arrangements. The following are examples of genera with di- or tri-trimerous floral whorls. The periods indicate the four floral whorls—sepals, petals, stamens, and carpels :—

Asimina : 3 . 3+3 . ∞ . 3 to 15.
Magnolia : 3 . 3+3±15 . ∞ . ∞ .
Cocculus : ♂, 3+3 . 3+3 . 3+3 . ♀, 3.
Lardizabala : 3+3 . 3+3 . 3+3 . 3.
Berberis : 3; 3+3 . 3+3 . 3+3 . 1.
Brasenia : 3+3 . 0 . 12 to 18 . 6 to 18.
Cabomba : 3+3 . 0 . 3+3 . 3.
Symmeria : ♂, 3+3 . [3+3] . 20 to 50 . ♀, 3.
Polygonum : 5 . [5] . 5 or 8 . 3.
Rumex : 3+3 . [3+3] . 3+3 . 3.

---

* "On the Variations of the Angular Divergences of the Leaves of *Helianthus tuberosus*," Trans. Linn. Soc. xxvi. (1868) p. 647; "On the Origin of the prevailing Systems of Phyllotaxis," Trans. Linn. Soc. ser. 2, Bot. vol. i. (1875) p. 37; "On the Origin of Floral Æstivations, &c.," Trans. Linn. Soc. ser. 2, Bot. vol. i. (1876) p. 177.

Besides the last three genera of Polygonaceæ, a few others might be mentiond, as genera of Lythrarieæ, &c.

The question is, how did these ternary verticils arise, if the ordinary phyllotaxis is $\frac{2}{5}$? With the exception of Calycanthaceæ, which have opposite leaves, all the rest have, as a rule, the quincuncial arrangement, or $\frac{2}{5}$.

An important fact to observe is the ease with which the phyllotaxis can be changed from one angular divergence to another, or from any one kind to what I have elsewhere called "tricussate" whorls, *i. e.*, successive whorls of threes alternating in position. This is facilitated by the fact that there are always three leaves, or whatever may represent them, in any portion of the spiral of any divergence (excepting, of course, $\frac{1}{2}$), "cut at random" and sufficient to make a circle when projected on a plane.

As the first illustration we may take *Chimonanthus* *. This has an indefinite number of bracts, sepals, and petals, with no break between them except in the size and colouring of the innermost members. The diagram given by Le Maout and Decaisne † shows the $\frac{2}{5}$ arrangement in the outer series concluding internally with eight larger parts, which may be regarded as petals, and arranged on the $\frac{3}{8}$ plan. Then follow 5 perfect stamens and 5+5 abortive ones. In the centre is represented a whorl of 5+5 carpels; thus the $\frac{2}{5}$ divergence prevails throughout, with one departure in the petals.

A point here worth noticing—which is well illustrated by Chimonantheæ as well as by members of Cactaceæ—is that the calyx is developed out of leaves, or rather bracts; while the corolla—though, as a rule, it issues out of stamens—*can* be produced as well from "below upwards," instead of the reverse, as in Water-Lilies. In *Calycanthus* there are no breaks between bracts, sepals, and petals, the abrupt change occurs with the stamens. The coloration increases inwards as well as the size of the parts. In *Epiphyllum* the colour is the same throughout.

That the coloured di-trimerous whorls of the calyx of *Anemone* issue from the leaves is indicated by the fact that one or more leaves of the involucre have not infrequently the same form and colour as the true sepals; while, on the other hand, the outer stamens may become more or less petaloid staminodia and secrete honey (*A. Pulsatilla*), as in *Atragene* compared with *Clematis.*

Moreover, when polyandrous flowers become double, the calyx usually remains unaltered, while the number of petals may increase to any extent.

When, therefore, the sepals increase in number, they are added to from below, as in *Anemone japonica*, in which it may consist of 3, 3+3, or 3+3+3 whorls; while in *A. Hepatica* the involucre becomes a floral whorl.

I will now explain how di-trimerous whorls—i. e., *two* whorls of *three* parts each—correspond to *one* cycle of the $\frac{2}{5}$ arrangement and require *two* complete *coils* or circles.

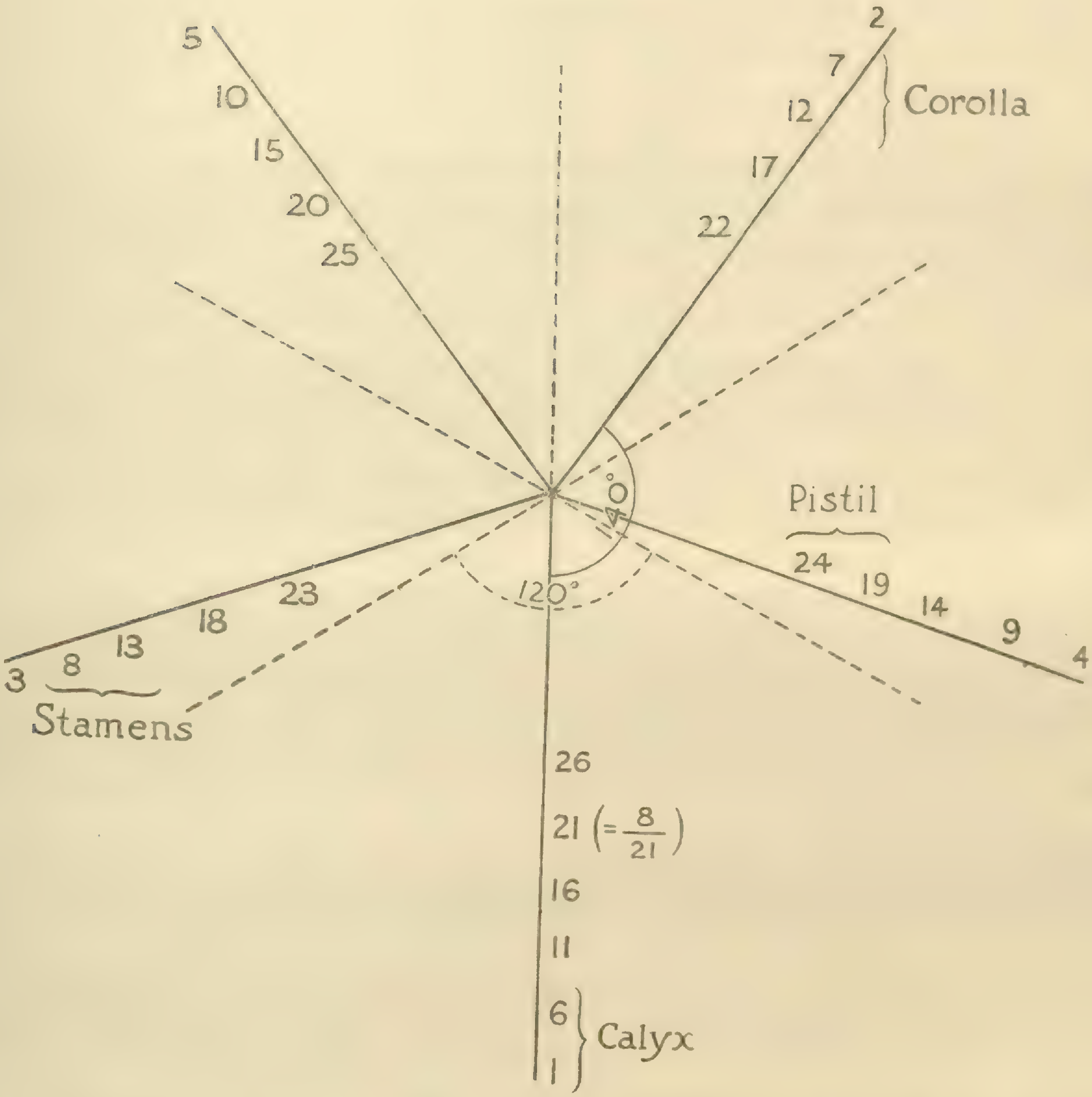
Figure 1 (p. 155) represents the $\frac{2}{5}$ divergence; numbers 1 to 5 form the first cycle ‡, but the *two* coils are not completed until No. 6, over No. 1, is reached. This—which

* This genus and *Calycanthus* are the only ones of the order Calycanthaceæ.

† 'Descriptive and Analytical Botany,' p. 191.

‡ This gives rise to the usual quinary arrangement in Dicotyledonous flowers.

Fig. 1.



This figure illustrates the method of obtaining di-trimerous whorls from the $\frac{2}{5}$ divergence. The numbers are arranged in accordance with this angular divergence of 144°. Nos. 1–5 constitute a *cycle of leaves*; but 1–6 complete 2 *coils* or circles when projected on a plane as for whorls. Herein No. 6—that is, the first member of the second cycle—is taken over to complete the di-trimerous whorls supplying the calyx. Nos. 7–12, 13–18, similarly determine the di-trimerous whorls of the corolla and stamens; but the pistil is represented as composed of 3 carpels, because this number really completes a *single cycle* of the $\frac{8}{21}$ divergence; all the other whorls, as stated, being deducible from the $\frac{2}{5}$ divergence.

The dotted lines, together with the initial line in front, show the final positions taken up by the members of the flower—thus giving rise to the three di-trimerous whorls and one trimerous whorl.

if the spiral were continued, would be the first number of the second cycle—is taken in to complete *two* whorls of three parts each: the 144° being now changed to 120° between any two successive parts.

Starting afresh with No. 7, 7 to 12 make the next two trimerous whorls, and so on.

If there be tri-trimerous whorls, then the one cycle of $\frac{3}{8}$ divergence is taken together with the first number of the next, so that the result is 3+3+3.

It will be observed that No. 21 falls over No. 1, this number of parts having required *eight* coils or circles; so that the whole of the floral whorls, calyx, corolla, stamens, and carpels utilize the 21 numbers, that is, a single cycle of $\frac{8}{21}$; though each pair of whorls was formed out of a single cycle of $\frac{2}{5}$. The dotted lines show the positions of the parts of the whorls.

The genus *Anemone* is one of an order characterized by having quinary flowers; and although it usually has six sepals, as in *A. Pulsatilla*, they may vary from 5 to 9. Thus *A. nemorosa*, *ranunculoides*, and *Coronaria* (in Malta) have often 5 sepals. The characteristic involucre of three parts has these on the $\frac{1}{3}$ divergence. In *A. Hepatica* it takes the form of an extra whorl, so that with the 6 sepals it follows the $\frac{3}{8}$ plan.

In *A. japonica* each member of the involucre has a floral peduncle in its axil, while the calyx may have 3+3, 5, or more sepals. There is a well-marked internode between the innermost sepals and the stamens, showing that the origin of the calyx is *not* due to the andrœcium, but to the foliage; though now and then one or more stamens may be petaloid in part. Hence $\frac{1}{3}$, $\frac{2}{5}$, and $\frac{3}{8}$ are all represented in the calyx, the two latter divergences being especially characteristic of Dicotyledons.

Turning to the foregoing list of examples, *Lardizabala* will illustrate the preceding observations; and the reader will at once perceive the difference between such a flower and that of any common Monocotyledon, as of *Alisma* or of a Tulip, with ternary whorls. These Monocotyledonous perianths, representing calyx and corolla, consist of only two whorls of three parts each—the whole flower being represented as 3 . 3 . 3, 3 . 3; the periods marking off the four floral whorls, but the comma separating two distinct cycles of stamens. On the other hand, *Rumex* should be represented as deficient in the corolla, thus: 3+3 . [3+3] . 3+3 . 3. The dislocation of the stamens (two being in front of each outer sepal) points to the absence of an intermediate whorl; the whole number of parts being 21, representing a cycle of the $\frac{8}{21}$ arrangement. Having once changed cycles of fives ($\frac{2}{5}$) into whorls of threes, or the one cycle of twenty-one parts ($\frac{8}{21}$) on the continuous spiral line, such can be increased in number upwards or downwards, by making additional "staminodal" petals as in *Magnolia*, or bracts may become petaloid and add trimerous whorls below the calyx, as occurs, *e. g.*, in Berberideæ and Menispermeæ. In this latter order, the genera are mostly with 3+3 . 3+3 . ♂, 3+3 . ♀, 3. But they may have the following numbers in the calyx, 3+3+3 (*Coscinium*) or 3+3+3+3 (in *Botryopsis*) (Benth. & Hook. fil. 'Genera Plantarum').

Berberideæ have mainly di-trimerous whorls; but three genera are tetramerous. "Fours" can only be derived from "fives" by "symmetrical reduction"*. I would,

* "Note on the Causes of the Numerical Increase of Parts of Plants," Journ. Linn. Soc., Bot. vol. xvi. (1877) p. 208.

therefore, assume hypothetically that the primitive ancestors were 5-merous; from which *Epimedium*, *Aceranthus*, and *Jeffersonia*, which are 4-merous, were thus derived.

Of the other genera the four following show gradations:—

Nandina: Br. S. and P, ∞ (*gradatim mutata*) . 3+3 . 1.
Vancouveria: Br. ∞ (*gradatim mutata*); 3+3 . 3+3 . 3+3 . 1.
Berberis: Br. 3; 3+3 . 3+3 . 3+3 . 1.
Diphylleia: 3+3 . 3+3 . 3+3 . 1.

An interesting example of the combination of 5's and 3's on the same plant has been given by Eichler, who has called attention to the fact that while the formula of the ordinary flowers of the raceme of the Barberry is Br. 3; 3+3 . 3+3 . 3+3 . 1, when a terminal flower is present its formula is 5 . 5 . 5 . 1; *i. e.* the $\frac{2}{5}$ arrangement *. The foliage of *Mahonia* is $\frac{2}{5}$; but the bracts of the inflorescence consist of twenty-one, in whorls of threes. The "cone" of buds within stand in six vertical rows.

Nymphæaceæ have both pentamerous and trimerous whorls, even in the same genus.
Nuphar luteum: 5 . 5+5 ($\pm$10 staminodal) . ∞ . 5+5 ($\pm$20).
N. advena: 3+3 . ∞ (including staminodal) . ∞ . ∞.
Brassenia: 3+3 . 0 . 12–18 . 6–18.
Cabomba: 3+3 . 0 . 3+3 . 3.

Bentham and Hooker describe the two latter genera as having both calyx and corolla of 3 members each; but as they are coloured alike, and practically make a perianth, I prefer to group them together as derived from a cycle of the $\frac{2}{5}$ arrangement.

We thus see that fives and threes not only distinguish different genera but even different species of the same genus.

Magnolia grandiflora supplies a case in which the corolla is often largely increased by staminodal petals. The calyx consists of three *sessile* and imbricated sepals. Then follow two or three whorls of three petals each. The petals are large, nearly equalling the sepals, but are provided with short claws, never being truly sessile. A variable number of "staminodal" petals (from 1 to 17, but 3 and 15 prevailing, were noticed).

Referring the whorls to their phyllotactical origins, the leaves are $\frac{2}{5}$; the three sepals $\frac{1}{3}$; if there be two whorls of petals, they are referable to $\frac{2}{5}$, as explained; if three whorls, to $\frac{3}{8}$. The stamens are $\frac{13}{34}$ and the carpels $\frac{8}{21}$.

The staminodal petals are thus distinguished, inasmuch as they are often very much smaller than the true petals, and each stands in the place of a stamen at the end of a secondary spiral, leaving a slightly larger scar than does a true stamen; whereas the insertion of a true petal occupies a space equal to at least three staminal scars. The variation in the number of staminodal petals arises from the fact that besides the last or lowermost stamen of a spiral being represented by a small petal, sometimes one or two more on the same individual spiral line may be petaloid as well.

Polygonaceæ supply further interesting illustrations of the origin of threes from the

* See Vine's 'Student's Text-book of Botany,' p. 498, fig. 311 [the anther on the left should be on the *innermost* coil and end of the spiral line], and p. 595.

$\frac{8}{21}$ arrangement. Thus, taking *Rumex*, we have, supplying the corolla, 3+3 . [3+3] . 3+3 . 3=21 ; while *Fagopyrum*, like *Polygonum*, shows the attempt to combine threes with fives. Thus, *P. Persicaria* has 5 . [5] . 3+5 . 3 * =21 with 8 circles. This may be regarded as partially descending from $\frac{8}{21}$ to $\frac{2}{5}$ and $\frac{1}{3}$. Flowers of *P. Hydropiper* examined were always 5 . 0 . 5 . 3.

In some cases a supernumerary whorl of stamens has been introduced. Thus *Rheum* has 3+3 . [3+3] . 3+3+3 . 3. But the number of stamens may vary from 3 and 6 to 9.

I have elsewhere † described how the stamens arise in *Rheum* by tracing their fibro-vascular cords :—"Three sepaline cords give rise to the three staminal (*i. e.* in front of the sepals), while six others arise in pairs. The remainder (*i. e.* three in number) are formed from the sepaline which have *not* given rise to the cords of stamens; these supply the carpellary cords." Hence it will be seen that the "pairs" arise from the *axis* where the petals ought to be, the cords of which have supplied those of the pairs of stamens instead.

One genus of this order carries us back to what was possibly a more primitive condition of a long spiral. *Symmeria*, as given by Bentham and Hooker, has (♂) 3+3 . [3+3] . 20–50 . 0; (♀) 3+3 . [3+3] . 0 . 3. Here the corolla only is supplied, while the 20–50 may mean whorls of fives; or *if* more, perhaps they might *accurately* be 21 to 55; *i. e.* cycles of $\frac{8}{21}$ and $\frac{34}{55}$.

Lythrariеæ supply some interesting corroborations. In the genera of this order the calyx is gamosepalous ‡. This necessitates the two whorls appearing as one, composed of six parts. The corolla follows suit, but the stamens reveal themselves as multiples of three. Thus the formula of *Lagerstrœmia* is, 6 . 6 . ∞ . 3, that of *Lythrum* being, 6; 6 . 3+3, 3+3, 3+3 . 2.

In some species of *Lythrum* symmetrical reduction has taken place, and we find 4; 4 . 4 . 4+4 . 2. The first number represents the teeth-like appendages.

The central flower of the 3-flowered cyme of *L. Salicaria* may be 7- or 6-merous ; when this occurs, the two lateral flowers are 6- or 5-merous, respectively.

Peplis, 6; 6 . 6 . 3+3 . 2, or else, but rarely, 5 ; 5 . 5 . 5 . 2.

The angular distance between any two consecutive parts in the $\frac{2}{5}$ arrangement is 144°, and between any two in a whorl of three is 120°. This, as observed, offers no difficulty in nature ; such changes are frequent. Thus, on vertical shoots of the common Laurel, the leaves are arranged on the $\frac{2}{5}$ plan ; but on the lateral horizontally growing branches the leaves are $\frac{1}{2}$. It is the same in the Ivy, the free-growing leaves are $\frac{2}{5}$, but those on

* The position of the three extra stamens is somewhat anomalous. The sepals are quincuncial, or $\frac{2}{5}$. The petals, which should *alternate* with the sepals, are wanting; then the *apparently outer* whorl of five stamens is *also alternate* with the sepals; but the three inner stamens *are opposite* sepals. I would suggest as an explanation that these three are the representatives of the *outer* whorl; but, as in *Geranium*, they have become dislocated in consequence of the presence of glands, so that they may either represent a whorl of five, or else be a single cycle of $\frac{1}{3}$ divergence. If the latter, then the whole number would make a single cycle of $\frac{8}{21}$.

† "The Vascular Systems of Floral Organs," Journ. Linn. Soc., Bot. vol. xxviii. (1889) p. 151.

‡ The tube is probably of a receptacular nature.

the climbing stem are $\frac{1}{2}$. In these cases light appears to be the determining cause; but when whorls are formed, as in flowers, say, in 5's, the number may increase to 6's or diminish to 4's, as may be seen in any corymb of Elder. Such differences are apparently due to varying amounts of nutriment *.

Turning now to Monocotyledons, the ternary arrangement of the floral whorls is the result of the $\frac{1}{3}$ arrangement. Commencing with a spiral of three leaves, at 120° apart, the fourth leaf would be over the first; but on projecting the spiral on to a plane, No. 4 takes a position 60° further on, in accordance with the "Law of Alternation" for whorls. No. 4, now starting the second whorl, would bring No. 7 over it, but this appears 60° further on and consequently stands over No. 2, and so on, as shown in Fig. 2. No. 21 will be seen to fall over the first, and as it is arrived at after eight revolutions, it represents the $\frac{8}{21}$ divergence; see Fig. 2, p. 160.

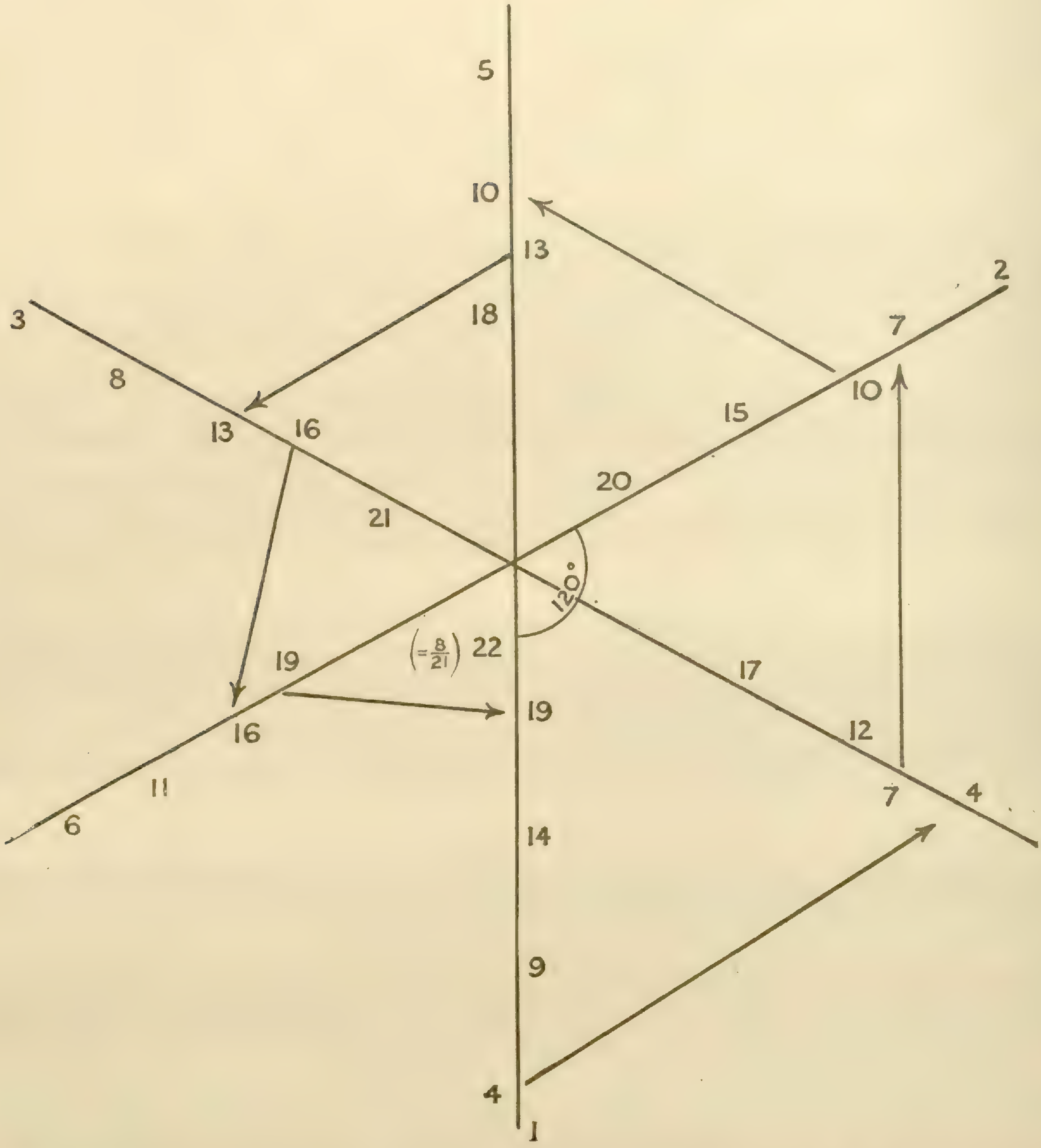
In *Paris* alone, so far as I know, may a quinary arrangement be found in the flower, a general floral formula being 4, 5 or 6 . 4, 5 or 6 . 8, 10 or 12 . 4 or 5. When quinary the members of the perianth are (according to Le Maout and Decaisne) distinctly quincuncial, or $\frac{2}{5}$. The explanation is as follows:—We have seen that among Dicotyledons a spiral arrangement can readily pass from one divergence to another, as $\frac{2}{5}$ to $\frac{3}{8}$ or *vice versâ*, and more rarely into $\frac{1}{3}$, or even $\frac{1}{2}$, as in Laurel and Ivy. Similarly, $\frac{1}{3}$ has passed upwards into the next divergence or $\frac{2}{5}$ in the floral whorls of *Paris*, and even in the foliage of some Lilies, as *Lilium speciosum*, and into higher ones, as $\frac{5}{13}$ or $\frac{8}{21}$ in Pineapples. But, whereas $\frac{2}{5}$ is the *origin* of all others in Dicotyledons, $\frac{1}{2}$ or $\frac{1}{3}$ is the *origin* and precedes all others in Monocotyledons. Hence the presence of $\frac{2}{5}$ in *Paris* is purely accidental and offers no indication of a Monocotyledon giving rise to a Dicotyledon, any more than ternary whorls in the latter.

Other indications of floral affinities with Dicotyledons might be thought to be traceable in a few quaternary flowers occurring in Aspidistreæ, Cyclantheæ, and *Potamogeton*; but if the flowers of pond-weeds be examined it will be found that they have *two pairs* of imbricated opposite leaves to the perianth, with *two pairs* of opposite stamens and a pistil of four carpels. These are easily deduced from whorls of threes by symmetrical reduction, the floral formula being 2 . 2 . 2, 2 . 2, 2. Degradations of various kinds among flowers of aquatic plants are a general phenomenon.

It may be noted that while the leaves of the perianth of *Potamogeton* are imbricated, they are valvate in Cyclanthaceæ; thus the latter exhibit a still further degree of degradation. I would repeat, in order to emphasize the fact, that the fundamental difference between the ternary whorls of flowers of Dicotyledons and those of Monocotyledons is thus seen to be that in the latter *each whorl* of three members corresponds to a *single cycle* of the $\frac{1}{3}$ divergence, whereas in the former there are—at least of some whorls of the flowers—*two circles* of three members each, corresponding to a *single cycle* of the $\frac{2}{5}$ divergence; or, if there be three circles of three members each, then such will be referable to a single cycle of the $\frac{3}{8}$ divergence. If there be more than three circles of three parts each, then they are *parts* of the single cycle of $\frac{5}{13}$, $\frac{8}{21}$, or $\frac{13}{34}$, &c.; the petals being

* See paper on "Numerical Increase, &c." cited on p. 156.

Fig. 2.



In this diagram of a spiral of the $\frac{1}{3}$ divergence, the first cycle contains the numbers 1, 2, 3; No. 4, which would begin a new cycle, naturally falls over No. 1; but in establishing whorls the "law of alternation" interferes and shifts No. 4 through 60°, as indicated by the arrow. Hence the second cycle now contains 4, 5, 6. No. 7 would similarly fall over No. 4, but it is also shifted through 60°, and so on for the Nos. 10, 13, 16, and 19.

The result is a series of *single cycles* of three members each, giving rise to *separate whorls* of threes, a true di-trimerous whorl being impossible. The first two whorls are often quite distinct, as a calyx and corolla, as in *Hydrocharis*, *Alisma*, and *Tradescantia*; but, of course, more often they are alike, forming the so-called perianth. Similarly the two cycles or whorls of three stamens each now form one, what might be called falsely acquired, di-trimerous whorl, since the $\frac{2}{5}$ divergence is extremely rare in the foliage of Monocotyledons.

usually staminodal (e. g. *Magnolia*) or developed out of bracts (e. g. *Calycanthus* and *Epiphyllum*).

It is therefore quite impossible for the ternary arrangements of flowers of Dicotyledons, having *two* circles of three members each (*i. e.* for a calyx, corolla, stamens, or carpels), to be derived from Monocotyledons; because the $\frac{1}{2}$ and $\frac{1}{3}$ divergences in the foliage are the *immediate* consequence of the single cotyledon, whereas the $\frac{2}{5}$ divergence follows at once from an opposite pair of cotyledons or leaves.

Hence it is seen why the flower of a Tulip really consists of an outer cycle (calyx) of three parts, an inner one of three parts, the two forming the perianth, 3, 3 stamens, *i. e.* two cycles of three parts each and three carpels. The calyx and corolla are well differentiated in *Hydrocharis*, *Alisma*, *Tradescantia*, and others.

To place two examples, for a contrast, together—*Rumex* has 3+3 . [3+3] . 3+3 . 3, or 21 parts in all, composed of three single cycles of the $\frac{2}{5}$ divergence, with three extra parts, *i. e.* 21 in all, thus forming *one cycle* of the $\frac{8}{21}$ divergence. *Hydrocharis* has 3 . 3 . (♂) 3, 3, 3, 3 . (♀) 3, 3; *i. e.* a continuous succession of *single cycles* of the $\frac{1}{3}$ divergence.

It may be noted that, although the passage from opposite leaves to $\frac{2}{5}$ is carried out by degrees, as I have shown in the case of the Jerusalem Artichoke and small species of *Epilobium*, it more often occurs *suddenly* without any intermediate stages, as in germinating acorns, the first leaves of the plumule being pentastichous. Nor is there any transition between $\frac{2}{5}$ and $\frac{1}{2}$ in the Laurel and Ivy described above.

It may be desirable to add a few words in explanation of the reason why the phyllotaxis of the floral whorls can change from one divergence to another. It is because they are *all* "represented" on one and the same axis when the parts are numerous and compacted together. Thus, in the cone of the Spruce-fir, the most nearly vertical rows (21 in number) are in accordance with $\frac{8}{21}$. The next two in height running to the right and left, respectively, represent $\frac{5}{13}$ and $\frac{3}{8}$. The next lower pair will stand for $\frac{2}{5}$ and $\frac{1}{3}$; while even $\frac{1}{2}$ can be shown to be present when *all* the scales are properly numbered.

Now, spirals can surrender, as it were, 3, 5, or 8 elements to make any whorl; but not 13, as a too awkward number for a whorl. It might be asked, if all the leaves or their representatives, as bracts &c., form a continuous spiral, say of $\frac{13}{34}$ divergence (*e. g.* the stamens of *Magnolia*), why should such definite "cycular" numbers as 3, 5, 8 be detached, as it were, and not any, different, numbers be given up to make a floral whorl? The answer is not forthcoming; but Nature seems to have some predilection for them. This is well seen in the ray-florets of Composites, when large numbers are counted. Thus with the Ox-eye Daisy and Sunflower, the ray-florets gave 21 as by far the largest maximum; also 13, 26 (=2×13), and 34 as much lower maxima.

The petals of the Cowslip gave as maxima 3, 5, 8, 10 (=2×5); 4, 7, 9 being minima.

Many other cases are known. A correspondent in the South of Europe tells me that he has observed that the maxima 21 and 34 occur in Marigolds and are correlated to their habitats. Thus 21 is the usual or typical number; but near the sea the maxima are 26 (=2×13) and 34.

"The Ox-eye Daisy," he writes, "has generally 21 ray-florets at the level of Lake Como; but at a height of 400–500 feet a form is developed *during the height of the flowering season* with 34 ray-florets, but it reverts to 21 later on."

A remarkable instance of the effect of habitat is seen in *Ranunculus Ficaria.* In Surrey and Guernsey the prevailing number of sepals was 3, or 99 p. c.; that of the petals being 8, or 86 p. c. Whereas at Gais the prevailing number of sepals was 5, or 61 p. c.; while that of the petals was 10, or 29 p. c. The inference I would draw from this is that the latter represents the ancestral quinary arrangement characteristic of the genus (or $\frac{2}{5}$). This has been surrendered to $\frac{1}{3}$ and $\frac{3}{8}$ in the prevailing 3 sepals and 8 petals, in consequence of one cotyledon being arrested and the foliage following suit by being $\frac{1}{2}$—just as it is in Monocotyledons generally. This result is presumably referable to an ancestral aquatic habit.

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s*. to the public, and 6*s*. to Fellows; to Vols. 26–30, 4*s*. to the public, and 3*s*. to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

Second Series.—Botany.

Volume.	Part	When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
I.	Part I.	1875.	0	8	0	0	6	0
	Part II.	1875.	0	16	0	0	12	0
	Part III.	1876.	0	12	0	0	9	0
	Part IV.	1876.	0	10	0	0	7	6
	Part V.	1878.	1	4	0	0	18	0
	Part VI.	1879.	1	6	0	0	19	6
	Part VII.	1880.	1	4	0	0	18	0
	Part VIII.	1880.	1	1	0	0	16	0
	Part IX.	1880.	1	0	0	0	15	0
II.	Part I.	1881.	0	12	0	0	9	0
	Part II.	1882.	0	5	0	0	3	9
	Part III.	1883.	0	10	0	0	7	6
	Part IV.	1883.	0	3	0	0	2	3
	Part V.	1883.	0	3	0	0	2	3
	Part VI.	1884.	0	13	6	0	10	0
	Part VII.	1884.	0	9	6	0	7	0
	Part VIII.	1884.	0	10	0	0	7	6
	Part IX.	1886.	0	7	0	0	5	0
	Part X.	1887.	0	3	4	0	2	6
	Part XI.	1886.	0	6	0	0	4	6
	Part XII.	1886.	0	8	0	0	6	0
	Part XIII.	1887.	1	7	0	1	0	0
	Part XIV.	1887.	0	7	0	0	5	0
	Part XV.	1887.	0	10	0	0	7	6
	Part XVI.	1888.	0	2	6	0	2	0
III.	Part I.	1888.	3	12	0	2	14	0
	Part II.	1891.	0	5	0	0	3	9
	Part III.	1891.	0	7	0	0	5	0
	Part IV.	1891.	0	6	0	0	4	6
	Part V.	1891.	0	6	0	0	4	6
	Part VI.	1891.	0	3	6	0	2	8
	Part VII.	1892.	0	6	0	0	4	6
	Part VIII.	1893.	0	6	0	0	4	6
	Part IX.	1893.	1	8	0	1	1	0
	Part X.	1894.	0	10	0	0	7	6
	Part XI.	1894.	0	3	4	0	2	6

Second Series.—Botany (*continued*).

Volume.	Part	When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
IV.	Part I.	1894.	1	0	0	0	15	0
	Part II.	1894.	2	0	0	1	10	0
	Part III.	1895.	2	10	0	1	17	6
	Part IV.	1895.	0	3	4	0	2	6
V.	Part I.	1895.	0	9	0	0	6	9
	Part II.	1895.	0	12	0	0	9	0
	Part III.	1896.	0	6	0	0	4	6
	Part IV.	1896.	1	0	0	0	15	0
	Part V.	1896.	0	14	0	0	10	6
	Part VI.	1896.	0	4	0	0	3	0
	Part VII.	1897.	0	4	0	0	3	0
	Part VIII.	1897.	0	6	0	0	4	6
	Part IX.	1899.	0	12	0	0	9	0
	Part X.	1899.	0	6	0	0	4	6
	Part XI.	1899.	0	7	0	0	5	0
	Part XII.	1899.	0	12	0	0	9	0
	Part XIII.	1900.	0	1	6	0	1	2
	Part XIV.	1900.	0	3	0	0	2	3
	Part XV.	1901.	0	6	0	0	4	6
VI.	Part I.	1901.	1	10	0	1	2	6
	Part II.	1901.	0	6	0	0	4	6
	Part III.	1902.	0	18	0	0	13	6
	Part IV.	1903.	0	8	0	0	6	0
	Part V.	1903.	0	8	0	0	6	0
	Part VI.	1903.	0	12	0	0	9	0
	Part VII.	1904.	0	12	0	0	9	0
	Part VIII.	1904.	0	12	0	0	9	0
	Part IX.	1904.	0	7	0	0	5	3
	Part X.	1904.	0	14	0	0	10	6
	Part XI.	1905.	0	4	0	0	3	0
VII.	Part I.	1904.	0	5	0	0	3	9
	Part II.	1905.	0	6	0	0	4	6
	Part III.	1906.	0	3	0	0	2	3
	Part IV.	1906.	0	7	0	0	5	3
	Part V.	1907.	0	10	0	0	7	6
	Part VI.	1907.	0	4	0	0	3	0
	Part VII.	1907.	0	6	0	0	4	6
	Part VIII.	1908.	0	5	0	0	3	9
	Part IX.	1908.	0	2	6	0	2	0

2nd Ser. BOTANY.] [VOL. VII. PART 10.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

MARINE ALGÆ (CHLOROPHYCEÆ AND PHÆOPHYCEÆ) AND MARINE PHANEROGAMS OF THE 'SEALARK' EXPEDITION, COLLECTED BY J. STANLEY GARDINER, M.A., F.R.S., F.Z.S.

BY

A. GEPP, M.A., F.L.S., AND MRS. E. S. GEPP.

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

December 1908.

X. *Marine Algæ* (Chlorophyceæ *and* Phæophyceæ) *and Marine Phanerogams of the 'Sealark' Expedition, collected by J. Stanley Gardiner, M.A., F.R.S., F.L.S.*

By A. Gepp, *M.A., F.L.S., and* Mrs. E. S. Gepp.

(Plates **22–24.**)

(Read 18th June, 1908.)

The following is a list of the Chlorophyceæ and Phæophyceæ collected by Mr. J. Stanley Gardiner during the 'Sealark' Expedition to the Seychelles, Chagos Archipelago, and the adjacent islands of the Indian Ocean in 1905. The Rhodophyceæ and a few Cyanophyceæ still remain to be worked out.

The present list numbers 36 species of Chlorophyceæ and 13 species of Phæophyceæ, among which 6 are new to science—namely, *Microdictyon pseudohapteron*, *Struvea Gardineri*, *S. orientalis*, *Bryopsis indica*, *Cladocephalus excentricus*, and *Avrainvillea Gardineri*. In addition there are 2 new varieties of *Caulerpa* described by Madame Weber van Bosse and several other species of great interest. Of the novelties, *Microdictyon pseudohapteron* exhibits in its reticulum a new form of tenacular connection which, according to Major Reinbold, whose views on the genus will soon be published, warrants the creation of a special section or subgenus for its reception. *Bryopsis indica* proves to be the same species as Harvey's unnamed specimens from Ceylon, published as no. 99, Alg. exsicc. Ceylon; and it is also represented by other specimens from Ceylon and Mauritius in the British Museum and Kew Herbaria. *Cladocephalus excentricus* is an East-Indian species of Mr. M. A. Howe's new genus, which has hitherto been known only from the West Indies, and indeed from only two localities there.

As regards specially interesting species other than novelties, we would mention *Boodlea van Bossei*, of which we are able to add new records for the Indian Ocean based on specimens found by us in the Kew Herbarium; *Codium difforme*, which, though it has been collected by the 'Siboga' Expedition in the Malay Archipelago, has not yet been actually recorded from the Indian Ocean; *Tydemania expeditionis*, which has only been found once previously, viz., in the Malay Archipelago by Madame Weber van Bosse during the same expedition; *Udotea glaucescens*, now recorded for the first time from the Indian Ocean, its home being in the Pacific; *U. palmetta*, which has never, so far as we know, been collected since the original gathering, and the only specimens of which are preserved in the herbaria of Paris and Caen, but without record of original locality—indeed, till the present specimens were brought home by Mr. Gardiner no region even could be assigned as habitat of the true species, though we had reasons for

suspecting it to be an Indian Ocean plant. Mr. Gardiner's notes show that his specimens were dredged up from 45 fathoms; so presumably *Udotea palmetta* is a deep-water species, a fact which would account for its having escaped observation. *U. argentea*, Zanard., is another interesting species, which has remained unknown since Zanardini's time in consequence of the loss of the type. One of the factors which adds much to the interest and importance of Mr. Gardiner's collection is the careful record of the depth from which each specimen was obtained, a detail almost entirely neglected until recently by collectors. Now that deep-water forms are rendered more accessible by the use of the dredge, we are becoming better able to appreciate the range in depth of a given species and its accompanying change of form. A good instance of this is seen in *Avrainvillea amadelpha*, of which Mr. Gardiner procured both reef and deep-water specimens. Though differing greatly in habit, they are identical in structure; and the peculiar dwarfed and mutilated appearance of the reef form is adequately accounted for by the eroding action of strong currents or surf.

The specimens of *Caulerpa* have been determined by Madame Weber van Bosse, the authority and monographer of that genus, who has been so very kind as to examine and name all of them, and her report is incorporated in this list.

The plants of *Turbinaria Murrayana* and *T. ornata* are of special interest, inasmuch as they show a manner of propagation by stolons hitherto unrecorded for *Turbinaria*; though we believe that this mode of reproduction has been known for some time to Madame Weber van Bosse as occurring in the genus.

We would here offer our best thanks to Mr. Gardiner for entrusting to us the examination of this interesting collection, and to Madame Weber for so readily naming the specimens of *Caulerpa*, and also for demonstrating to us the identity of *Zonaria variegata*, a characteristic and widely-distributed species, which is ably treated in one of Monsieur Sauvageau's later papers. To *Z. variegata*, as we now see, must be referred *Ralfsia ceylanica*, Harv. To Major Reinbold we are indebted for the determination of *Boodlea van Bossei* and for valuable information concerning *Microdictyon* derived from his MSS., as yet unpublished. We postpone all remarks on geographical distribution until the rest of the Algæ have been named.

CHLOROPHYCEÆ.

ULVACEÆ.

Ulva (Linn.), Wittr., emend.

1. Ulva fasciata, Del. Flore d'Egypte, 1813, p. 153, tab. 58. fig. 5; De Toni, Syll. Alg. i. (1889) p. 114.

Seychelles: Praslin, on reefs exposed at dead low tide.

Geogr. Distr. Mediterranean. Atlantic. Pacific. Indian Ocean.

Both in form and structure this plant agrees with Harvey's specimen from Ceylon, no. 100.

CLADOPHORACEÆ.

Boodlea, G. Murr. & De Toni.

2. Boodlea van Bossei, Reinb. Neue Chlorophyc. Ind. Ocean, in Nuov. Notar. vol. xvi. (1905) p. 148.

Coetivy, on reefs exposed at dead low tide. Cargados Carajos, 45 fms.

Geogr. Distr. Malay Archipelago, 'Siboga' Expedition! Lucipara Islands, *fide Reinbold.* Mauritius. *Ayres*! in Herb. Kew. Seychelles, *Dupont*! in Herb. Kew. Diego Garcia, German Deep-sea Expedition, 'Valdivia,' 1898–9.

The specimens of this plant collected by Mr. Gardiner vary slightly in the size of the filaments, but they all show the distinguishing character of the long slender unbranched unicellular rhizoids which arise from any part of the thallus, and each bears at the end a well-developed tenaculum. Major Reinbold very kindly examined our plants, and referred them at once to his *Boodlea van Bossei*. We do not figure the plant here, since we understand that Major Reinbold will figure and describe it more fully in his forthcoming account of some of the 'Siboga' algæ. Though we have examined a number of other specimens in the British Museum Herbarium, we do not find a single specimen of *B. van Bossei*. In the Kew Herbarium, however, there was one specimen from the Seychelles and another from Mauritius.

During our search for *B. van Bossei* we found several hitherto unrecognised specimens of *B. coacta*, G. Murr. & De Toni, which we here take the opportunity of recording:—

3. B. coacta, G. Murr. & De Toni, in Journ. Linn. Soc., Bot. xxv. (1889) p. 245, t. 49.

Friendly Islands, Vavau, *Harvey*, no. 107 (sub "*Cladophora* sp.")! Friendly Islands, Lifuka, *Harvey*, no. 109 (sub "*Cladophora* sp.")! Mauritius Arsenal, no. 78 (collector unknown), July 1868 (in Herb. Mus. Brit.)! Mauritius, Barkly Islands, Jan. 1870, *Colonel Pike*, no. 148!

Microdictyon, Decaisne.

4. Microdictyon pseudohapteron, sp. n. (Plate 22. figs. 1–4.)

M. fronde ramellis radicantibus paucis substrato affixa, foliacea, e filamentis cylindricis primo opposite deinde stellatim ramosis inter sese reticulatim per pseudohaptera conjunctis composita.

Amirante, 20–44 fms. and 30–100 fms. Saya de Malha, 25 and 26 fms. Cargados Carajos, 45 fms.

The principal interest of this species lies in the fact that it diverges from the type of structure hitherto recognised as characteristic of *Microdictyon*. That genus, it will be remembered, consists of a network of short cylindrical cells situated in one plane only. Emerging on each side at the articulations of the main filaments, either singly at right angles to the main axis or in pairs at acute angles, the lateral branches with their branchlets come into contact with their neighbours and become attached to them, thus producing square or polygonal meshes. The main articulated filaments may be seen coursing like veins through this reticulated membrane. No true tenacula have hitherto

been described as occurring in *Microdictyon*; and we were therefore much interested to find that the apical attachment-points of the branchlets in our plant have the appearance of tenacula. We submitted our specimens to Major Reinbold, who has lately studied this genus and will shortly publish his conclusions in the reports of the 'Siboga' Expedition; and he kindly pointed out that the attachment-points in our specimens are not true tenacula—that is, specialised cells—but are merely crenellated cell-ends (fig. 3). They are, however, of sufficient importance to warrant his placing our species in a separate section of the genus, a matter which he will deal with in his forthcoming paper.

M. pseudohapteron may also be recognised by the ramification, which in mature parts of the thallus tends to be stellate at the nodes. This appears to arise in the following manner:—The main filaments at each transverse wall put out a pair of opposite branches in the same plane at right angles to the axis of the filament. Each of these branches is seen to be seated in a lateral notch, as shown in fig. 2, *c*. Subsequently these branches may become pulled or pushed forward so as to be situated at an acute angle with the apical part of the main filament. Usually a second branch emerges from the main filament in the axil below the first branch, and as it grows it tilts the first branch forward. Thus a stellate node is obtained (fig. 2, *d*), and this, as mentioned above, is characteristic of our species. Each branch repeats this mode of ramification more or less regularly, and the triangular or polygonal meshes become more and more subdivided, and sometimes almost filled in by the ultimate branchlets. As previously mentioned, the free ends of the branchlets become adherent to the sides of neighbouring cells, and thus the firm flat net of the thallus is formed.

Though most of the other species have a cruciform ramification, yet some of the species show in the same thallus both cruciform and stellate modes of ramification. Major Reinbold has seen this in Mediterranean specimens of *M. umbilicatum*, and the same may be seen in *M. calodictyon*, Decne., from the Canaries. This is also figured by Montagne in Webb and Berthelot's Hist. Nat. des Iles Canaries, iii. part ii. sect. iv. (1840) p. 180, tab. 8. figs. 1 *b*, 1 *c*. Curiously enough, Montagne describes the primary filaments as dividing into fours ("venis quinis, mediis erectis, binis inferioribus patentibus"). Kützing also figures the branching of *M. calodictyon* in his 'Tabulæ Phycologicæ,' vii. (1857) tab. 25, II.

Though we have not seen in our specimens the original attachment-disc, we have noticed several rhizoids which fasten the thallus to the substratum. They appear to be attenuated prolongations of the apex of a branchlet; sometimes they arise from the side of the cell. They are usually dark and partly opaque, and bear a holdfast at the extremity (fig. 4).

STRUVEA, Sond.

5. STRUVEA GARDINERI, sp. n. (Plate 22. fig. 5.)

S. stipite simplice, rugoso; fronde juniore subelliptico, 5 cm. longo, 3 cm. lato, fronde adultiore late expanso, circa 17 cm. longo, 15 cm. lato; reticulo laxo e rhachi inconspicua pinnatim ramosa et e ramis ad nodos cruciatim egredientibus iterum

iterumque in eodem modo cruciatim ramulosis composito; ramulis ultimis vel per tenacula affixis vel conspicue liberis; reticuli interstitiis in fronde juniore polygonis irregularibus 1–4 mm. diam., in fronde adultiore sæpe usque ad 10–20 mm. diam., hinc et illinc per lacerationem majoribus; margine integro. Cellulis rhacheos 7 mm. longis, 0·8 mm. latis; ramulorum 0·75–1·5 mm. longis, 0·3–0·6 mm. latis.

Cargados Carajos, 30, 45, and 47 fms.

Of this species we have four specimens, two consisting of a mature flabellum only without stalk, and the other two complete but small plants, the stalk of one being about 6·5 cm. long and the frond about 5 cm. The meshes of the flabellum are the largest we have seen in *Struvea*, the cells of the costa measuring as much as about 7 mm., the cells of the branches 3 mm., and those of the ultimate ramuli 0·75 mm. The branches and branchlets are opposite and the shape of the meshes is rectangular; the nodes are cruciate and not stellate, whereas in *S. orientalis*, the following species, the branching at the node is stellate.

Struvea Gardineri differs from *S. macrophylla* in the smaller width and greater length of the costa-cells, and in the irregularity and large size of the mesh as compared with the regular and close mesh of *S. macrophylla*. *S. Gardineri* differs from *S. orientalis* in having an unbranched stem, an entire margin, and a looser and rectangular mesh and cruciate nodes, the nodes of *S. orientalis* being stellate. *S. pulcherrima* is the nearest ally in point of size, but is easily distinguished by its stellately branched reticulum of small regular meshes like those of some species of *Microdictyon*.

6. Struvea orientalis, sp. n. (Plate 22. figs. 6–9.)

Planta solitaria vel plures ex eadem basi ortæ; stipite simplice vel diviso, rugoso vel lævi, 2·5–3·75 cm. longo, ramis plerumque oppositis; fronde basi cordato 3–5-costato supra irregulariter expanso et mutilato vel paucilobato, usque ad 4 cm. longo et lato; reticulo denso e rhachi pinnatim ramosa et e ramis ad nodos stellatim egredientibus iterum iterumque in eodem modo stellatim ramulosis composito, ramulis fere omnibus per tenacula affixis; ramulis marginalibus liberis; reticuli interstitiis parvis (0·1–0·3 mm. diam.) triangularibus vel polygonis et sæpe per ramulos ultimos fere omnino impletis. Cellulis racheos infra 3·0–3·5 mm. longis, 0·5 mm. latis, sursum gradatim decrescentibus; ramulorum 0·5 mm. longis, 0·25 mm. latis; cellulis ultimis 0·2–0·4 mm. longis, 0·1–0·15 mm. latis.

Amirante, 20–25 or more fathoms.

This species is represented by a group of four dried plants, all growing from a common base, with rhizoids interwoven, and also by a single plant preserved in formalin. The latter specimen is simple, bears an irregularly lobed frond, with margin not entire but composed of free projecting branchlets (fig. 7, *a*), and has rather dense finely granular cell-contents. Three of the dried plants are two or three times branched; the branching is truly opposite, but occasionally appears to be dichotomous, owing to the removal or loss of one of the branches. The branches themselves are possibly the persistent basal costæ of a denuded frond; but we cannot be certain of this. The fronds of these plants

are all so much torn that it is impossible to say what the normal outline of the fron may be. It consists of a close reticulum, the minute meshes of which are often almost completely filled in by cells or branchlets of later growth (figs. 7, *b*, and 8, *a*), somewhat recalling *Anadyomene*. The characteristic tenacula are well developed in this species (fig. 9).

The only branched species of *Struvea* hitherto described are *S. ramosa*, Dickie, and *S. delicatula*, Kütz. From the former of these, which is about equal in size, our plant differs in having a very much smaller mesh with cells half as long as those of *S. ramosa*. From *S. delicatula* it differs in being two to three times as large, and in having the reticulum of the frond composed of cells of approximately equal diameter, forming a much more uniform meshwork.

Anadyomene, Lamour.

7. Anadyomene Wrightii, Harv. apud J. E. Gray in Journ. Bot. iv. (1866) p. 48, tab. 44. fig. 5; De Toni, Syll. Alg. i. (1889) p. 367.

Saya de Malha, 26 fms. Cargados Carajos, 45 and 47 fms.

This species is not represented by authenticated specimens either in the British Museum or in the Kew Herbarium. But the excellent figure and description in J. E. Gray's paper have enabled us to determine our plants and to refer to this species no. 7 of Ferguson's Ceylon algæ.

Geogr. Distr. Loo Choo Islands. Ceylon.

VALONIACEÆ.

Dictyosphæria, Decne.

8. Dictyosphæria favulosa, Decne. Class. des Algues, p. 32; De Toni, Syll. Alg. i. (1889) p. 371; Weber van Bosse, in Nuov. Notar. xvi. (1905) p. 143.

Coetivy, on reef exposed at dead low tide. Saya de Malha, 25 fms. Cargados Carajos, 45 fms. Chagos Archipelago, Egmont reef, exposed at dead low tide.

Geogr. Distr. West Indies. Pacific Ocean. Indian Ocean.

9. D. Versluysii, Web. v. Bosse, in Nuov. Notar. xvi. (1905) p. 144.

Coetivy reef. Chagos Archipelago: Salomon and Egmont, on reefs exposed at dead low tide.

Geogr. Distr. Malay Archipelago.

As stated by the author (*l. c.*), this species is characterised by being solid throughout its life-history, and by bearing on the internal membrane of the cell cellulose hairs, which grow towards the interior. This species will be more fully described by Madame Weber in her official report upon the algæ of the 'Siboga' Expedition.

VALONIA, Ginn.

10. VALONIA CONFERVOIDES, Harv. Alg. exsicc. Ceylon, no. 73, and Alg. exsicc. Friendly Islands, no. 101; J. Agardh, Till Alg. Syst. viii. (1887) p. 100; De Toni, Syll. Alg. i. (1889) p. 378.

Coetivy reef. Chagos Archipelago: Egmont, on reef exposed at dead low tide.

Geogr. Distr. West Indies. Pacific. Indian Ocean.

11. V. FASTIGIATA, Harv. Alg. exsicc. Ceylon, no. 74, and Alg. exsicc. Friendly Islands, no. 100; J. Agardh, Till Alg. Syst. viii. (1887) p. 101.

Coetivy reef. Seychelles: Praslin reef. Saya de Malha, 25 fms. Cargados Carajos, 47 fms. Chagos Archipelago: Egmont reef.

Geogr. Distr. Indian Ocean. Friendly Islands. Australia.

NEOMERIS, Lamour.

12. NEOMERIS ANNULATA, Dickie, in Journ. Linn. Soc., Bot. xiv. (1873) p. 198; De Toni, Syll. Alg. i. (1889) p. 414; M. A. Howe, in Bull. Torrey Bot. Club, xxxi. (1904) pp. 97–99.

Coetivy. Chagos Archipelago: Egmont. In each case on reefs exposed at dead low tide.

Geogr. Distr. West Indies. Pacific: Tongatabu. Indian Ocean: Mauritius.

The material of this species is somewhat scanty, but ample for identification. The scarcity, however, is explicable in view of the inconspicuousness of the calcified plant to any eye but that of the expectant algologist. The species is synonymous with *N. Kelleri*, Cramer, and has been recorded from the West Indies, Polynesia, and Mauritius. If carefully searched for it will probably be found at other tropical stations. Mr. M. A. Howe (*l. c.*) has published a useful key to the three species of *Neomeris* and has given a bibliography of the literature.

BRYOPSIS, Lamour.

13. BRYOPSIS INDICA, sp. n. (Plate **22.** figs. 10, 11.)

B. frondibus erectis, usque ad 30 mm. altus, bifariam plus minusve ramosis vel simplicibus, pluma initiali ambitu oblanceolato-oblonga hinc illinc adparenter disticha circa 12·5 mm. longa, ramentis simplicibus singulis circa 1 mm. longis, in ordines duos ad quodque latus dispositis, raro paucis ordinibus duplicibus interpositis.

Coetivy. Chagos Archipelago: Coin, Peros. In each case on reefs exposed at dead low tide. Also Ceylon, *Harvey*! no. 99 Alg. exsicc. Ceylon. Mauritius, *Pike*! Gabriel Island, May 22/71, sub *B. cæspitosa* in Herb. Mus. Brit. and Kew.

Geogr. Distr. Indian Ocean.

This species is, like the West-Australian *B. australis*, Sond., distinguished by the

arrangement of the ramenta along the stem. Through a lens they sometimes appear to be distichous, as if forming single rows on the two opposite sides of the stem or branch (fig. 11), but a more careful examination shows that they form in reality two rows of alternating ramuli, instead of a single one, on each side. The ramenta emerge each singly from the stem, and do not bifurcate at the base as in *Bryopsis gemellipara*. Besides this simple arrangement of two double rows of ramenta, there are occasionally either one or two single or double rows of ramenta arising in the intermediate space between the original rows; and such plants have the appearance of bearing ramenta all round the stem until microscopically examined. This distribution of the ramenta is easily seen by a study of the scars left on the bare stem by the fallen ramenta. This mode of ramification separates our plant from the truly distichous group represented by *B. plumosa* and also from the group including *B. hypnoides*, in which the ramenta arise all round the stem.

The nearest ally to our plant is *B. australis*, which bears two double or triple rows of alternating ramenta. The difference between *B. australis* and our plant is found in the habit—*B. australis* having long bare branched stems, with short plumes at the top, 3–5 mm. long; while in *B. indica* the stems are much shorter and the plumes extend twice as far downwards from the apex (about 10 mm.) as in *B. australis*. In the latter species the ramenta, in fact, appear to be much more deciduous.

B. australis was discovered by Preiss in West Australia, and, so far as we know, has never been recorded since. Authentic specimens are preserved in the Herbaria of the British Museum and Kew, which witness to the truthfulness of Kützing's plate (Tab. Phyc. vi. tab. 81, i.) so far as concerns the general habit of the plant. The Kew specimen, for instance, consists of some half-dozen long bare stems, arising from a fragment of main stem and having at their base the clasping rhizoids so often present in *Bryopsis*. At the summit of each branch is a short lanceolate plume of unbranched ramenta, which were described by Sonder in Lehmann's 'Plantæ Preissianæ,' ii. (1846–7) p. 152, as arising in a subhexastichous order. It is strange that J. G. Agardh, in his 'Till Alg. Syst.' viii. (1887) p. 27, states that he has not observed this mode of arrangement, and describes the ramenta as "quoquoversum egredientibus," without further detail. Kützing (*loc. cit.*) is unsuccessful in portraying the terminal plume and the arrangement of the ramenta. These latter are far too few in the figure, and are represented as emerging all round the stem, as indicated by the scars below.

While examining other species of *Bryopsis* in the Herbaria of the British Museum and Kew, we have been able to identify several as *B. indica*, and thus add to the area of its distribution. Among these is Harvey's unnamed specimen issued in his 'Exsiccatæ' as *Bryopsis* sp., Ceylon, no. 99. Col. N. Pike also collected this species in Mauritius.

CAULERPACEÆ.

(By Madame WEBER VAN BOSSE.)

CAULERPA, Lam.

14. CAULERPA CRASSIFOLIA, J. Ag.

f. TYPICA, Web. v. Bosse.

C. pinnata f. *typica*, Web. v. Bosse, Monogr. des Caulerpes, in Ann. Jard. Bot. Buitenzorg, xv. (1898) p. 290.

Cargados Carajos, 30 fms.

Geogr. Distr. Ceylon.

15. C. TAXIFOLIA, J. Ag.

f. INTERRUPTA, Sved. in Rep. Ceylon Marine Biol. Lab. part ii. (1906) p. 32.
Cargados Carajos, 30 fms.
Geogr. Distr. Ceylon.

f. ASPLENIOIDES, Web. v. Bosse, *l. c.* p. 292.
Amirante, 30 fms.
Geogr. Distr. Ceylon. Malay Archipelago. Sandwich Islands.

16. C. FREYCINETII, Ag.
Var. TYPICA, Web. v. Bosse, *l. c.* p. 312.
Chagos Archipelago: Salomon, on reef exposed at dead low tide.
Geogr. Distr. West Indies. Red Sea. Indian Ocean. Pacific.

Var. TYPICA f. LATA, Web. v. Bosse, *l. c.* p. 313.
Seychelles: Praslin, on reef exposed at dead low tide. Chagos Archipelago: Diego Garcia, Barachois, on reefs exposed at dead low tide.
Geogr. Distr. West Indies. Red Sea. Ceylon. Malay Archipelago. Marianne Islands. Caroline Islands. Friendly Islands.

Var. TYPICA f. SPIRALIS, Web. v. Bosse, *l. c.* p. 314.
Chagos Archipelago: Salomon, Egmont and Diego Garcia, on reefs exposed at dead low tide. Amirante, 20–44 fms.
Geogr. Distr. New Caledonia.
The Amirante specimen shows less torsion and has bigger teeth than is usually the case in f. *spiralis*. The difference is probably due to the great depth from which the plant was collected.

17. C. CUPRESSOIDES, Web. v. Bosse, *l. c.* p. 323.
Coetivy, on reef exposed at dead low tide.
Geogr. Distr. West Indies. Indian Ocean. Pacific.

This is an intermediate specimen, standing nearer to var. *typica* than to var. *mamillosa* f. *nuda*.

Var. TYPICA f. DENUDATA, Web. v. Bosse, f. n.; rhachi passim pinnulis orbata, pinnulis parvis.

Cargados Carajos [depth unknown; probably about 30 fms.]. Farquhar Lagoon.

The main axis is in many parts bare of pinnules, and the pinnules where present are small. In the dried specimens the axis is a little constricted above a whorl of pinnules. This is, however, not always the case, and may be due to the drying process.

Var. TYPICA f. GARDINERI, Web. v. Bosse, f. n. (Plates 22, 23. figs. 12, 13); frondibus a surculo repente erectis elongatis dichotome ramosis fastigiatis, vel planis pro specie latis (1·5–2 mm.) pinnulas distichas gerentibus, vel triangularibus pinnulas regulares tristichas breves subnaviculares gerentibus.

Saya de Malha, 25 fms. Cargados Carajos, 28 and 45 fms.

The form *Gardineri* is another instance of the difficulty of distinguishing definitely the members of *Caulerpa cupressoides*. Some months ago I received from my friends Mr. and Mrs. Gepp a small collection of Mr. Stanley Gardiner's *Caulerpæ*, and among these I found the above-named form, but only with branches bearing distichous pinnules (fig. 12). These plants were dried specimens, and bore no indication of the depth at which they had been collected. The rather broad axis and the distichous pinnules pointed towards *C. Lessonii*, Bory, but the entire absence of cylindrical pinnules, the great length (20 cm. and more) of the branches, or "assimilators" as Svedelius calls them, made me think that this plant was a deep-water form of *C. cupressoides*.

A short time ago I received from Mr. and Mrs. Gepp some more *Caulerpæ* from the same collection for determination. This time the material was preserved in alcohol, and amongst it was this same form *Gardineri*. On the accompanying label was mentioned the depth from which the alga had been hauled up; it was 28 fathoms. Amongst these specimens there was one large plant with triangular regularly tristichous pinnules, all subnavicular (fig. 13). We know, and Svedelius in his beautiful paper on the *Caulerpæ* of Ceylon has described the fact at full length, that some species of *Caulerpæ* increase in length when they grow in places where the water is deep, and that other species do not. *C. cupressoides* seems to belong to the first category; but with the lengthening of the main axis we observe a reduction of the pinnules in size and often in number. The pinnules of the form *Gardineri* are smaller than the pinnules of *C. cupressoides* var. *typica*, and they are often distichous instead of tristichous, but specimens with tristichous pinnules do occur. The present form is new to science, and I have given it the name of *Gardineri*, in honour of Mr. Stanley Gardiner who collected it for the first time. Its characteristics are the great length of the assimilators and the regular, rather small, subnavicular pinnules, placed either distichously (fig. 12) along a rather broad, or tristichously (fig. 13) along a triangular, axis.

Var. MAMILLOSA f. NUDA, Web. v. Bosse, *l. c.* p. 332.

Chagos Archipelago: Diego Garcia and Coin, Peros. Coetivy. In each case on reefs exposed at dead low tide.

Geogr. Distr. West Indies.

CODIACEÆ.

CODIUM, Stackh.

18. CODIUM DIFFORME, Kütz. Tab. Phyc. vi. (1856) p. 35. tab. 99; Askenasy, in Forschungsreise 'Gazelle,' Theil iv. Bot. (1889) p. 10; Bornet, Algues de Schousboe (1892), p. 55.

Chagos Archipelago: Peros, on reefs exposed at dead low tide.

Geogr. Distr. Mediterranean. Kerguelen.

This species resembles in habit *C. adhærens*, Ag., but is quite distinct in the size of its utricles (peripheral cells), which measure about 1 mm. in length and 150–200 μ in diameter, while those of *C. adhærens* do not exceed 60 μ in diameter. These distinctions are pointed out by Askenasy and Bornet (*ll. cc.*).

19. C. OVALE, Zanard. Phyc. Papuanæ, in Nuov. Giorn. Bot. Ital. x. (1878) p. 37; De Toni, Syll. Alg. i. (1889) p. 491.

Seychelles, 31 fms.

Geogr. Distr. New Guinea.

20. C. TOMENTOSUM, Stackh. Ner. Brit. (1801) p. 21, tab. 7; De Toni, Syll. Alg. i. (1889) p. 491.

Amirante, 20–25 fms. and below 25 fms.

Geogr. Distr. Mediterranean. Atlantic. Cape of Good Hope. Indian Ocean. Pacific.

This species has a wide distribution in temperate and tropical waters. But since many specimens of similar habit have in the past been wrongly referred to it, caution should be observed in accepting all the specimens so determined in large Herbaria without re-examination of the utricles of the plants. The shape and average size of the utricles, the apex of the utricle whether thin-walled or thickened, whether mucronate or not—these, together with habit, are the distinguishing characters of the species.

21. C. ELONGATUM, Ag. Spec. Alg. (1849) p. 454; Kützing, Tab. Phyc. vi. (1856) tab. 96; De Toni, Syll. Alg. i. (1889) p. 496; Bornet, Algues de Schousboe (1892), p. 56.

Amirante, 20–25 fms. and below 20 fms.; Seychelles, 31 fms.

Geogr. Distr. Mediterranean. Indian Ocean. Australia.

In an interesting note upon this species Bornet (*loc. cit.*) points out that in distinguishing the forms of this and of the preceding species the most trustworthy character is found in the respective size of the utricles rather than in the external habit of the plants, and that the specific limits thus assigned accord well with the geographical

distribution on the west coast of Europe. The true *Codium tomentosum* has small utricles up to 500 μ in length and ranges as far north as Great Britain, whereas *C. elongatum* has large utricles, often twice as long as those of *C. tomentosum*, and does not seem to occur north of Cadiz. We find the same distinction to hold good for extra-European species.

Tydemania, Weber van Bosse.

22. Tydemania expeditionis, Weber van Bosse, in Ann. Jard. Bot. Buitenzorg, xvii. (ser. 2, vol. ii.) 1901, p. 139. (Plate 23. figs. 18, 19.)

Amirante, 20–44 fms. Chagos Archipelago: Salomon, on reefs exposed at dead low tide.

Geogr. Distr. Malay Archipelago.

For the sake of convenience we quote here the original diagnosis of this rare alga :—

"Thalle incrusté de calcaire, composé d'un axe cylindrique simple ou ramifié, portant des branches réunies en glomérules superposés ou rarement disposés en éventail. Branches se divisant par dichotomie répétée en directions alternantes en ramules très étalés, enchevêtrés, formant un glomérule dense, ou branches se divisant par dichotomie répétée en une seule direction en ramules érigés, conglutinés, en forme d'éventail. Fructification inconnue."

This plant seems to have eluded the observation of collectors until discovered and recorded by Madame Weber van Bosse when on the 'Siboga' Expedition to the Dutch East Indies, and it was briefly described by her in the diagnosis quoted above. The specimens which she has been so kind as to lend us show the remarkable dimorphic habit of the plant, and they will be figured among the 'Siboga' reports. But while her specimens chiefly represent the glomerulous form, those of Mr. Stanley Gardiner are of the flabellate form only, without a single example of the glomerulous form, and consist of tufts and masses of small flabellate calcified fronds connected together by a continuous branched filament. At first sight these flabella might easily be mistaken for *Udotea javensis*, Gepp (Journ. of Botany, xlii. 1904, pp. 363–4, pl. 467), formerly known as *Rhipidosiphon javensis*, Mont., since they consist, like that species, of calcified dichotomously branched filaments, adhering laterally in one plane. The stipes also, upon which the flabellum in each species is borne, is monosiphonous. But a comparison of the two species side by side shows at once unmistakable differences. In *T. expeditionis* the single siphon, which bears the flabellate fronds, is beaded from its point of junction with the main filament up to the point at which it divides to form the flabellum, while in *U. javensis* the monosiphonous stipes is entirely unbeaded and often emits rhizoids, as may be seen in our figures of the plant (*loc. cit.* figs. 2, 3 *a*). In the size of the filaments, both of stem and frond, there is considerable difference between the two species. The diameter of the stipes in *T. expeditionis* is about 250–280 μ and of the frond filaments 40–70 μ, while that of the stipes of *U. javensis* is 60–100 μ and of the frond filaments 30–40 μ.

UDOTEA, Lamour.

23. UDOTEA GLAUCESCENS, Harv. Algæ exsicc. Friendly Islands, no. 82; J. G. Agardh, Till Alg. Syst. viii. (1887) p. 70.

Cargados Carajos, 30 fms.

Geogr. Distr. Friendly Islands. Fiji. Cape York.

This species has not hitherto been recorded from the Indian Ocean, though its near ally *U. javensis*, Gepp (*Rhipidosiphon javensis*, Mont.), occurs in the Malay Archipelago and Ceylon.

24. U. CONGLUTINATA. Lamour. Polyp. flex. (1816) p. 312; De Toni, Syll. Alg. i. (1889) p. 507.

Amirante, 30 fms. Coetivy reef. Cargados Carajos, 30 and 47 fms.

Geogr. Distr. Atlantic. Indian Ocean. Pacific.

25. U. PALMETTA, Decne. Mém. sur les Corallines etc. in Ann. Sci. Nat. 2e sér. xviii. (1842) p. 105; De Toni, Syll. Alg. i. (1889) p. 506.

Cargados Carajos, 45 fms.

Geogr. Distr. Indian Ocean.

This species has, so far as we know, never been collected since the original plant was described by Decaisne (*l. c.*). The original locality whence this species came has never been recorded. It is indicated neither by Decaisne in his description nor on the label of the type specimen preserved in the Paris Herbarium. Decaisne merely says "in Herb. Petit Thouars, nunc Mus. Par." Through the kindness of Messrs. Hariot and Lignier we have been accorded the privilege of examining Decaisne's type now in Paris, as well as the specimen preserved in Herb. Chauvin at Caen, which together have hitherto constituted the only known material of the species. The home of *U. palmetta* remained therefore a mystery until the present collection of Mr. Stanley Gardiner yielded fresh examples, which point to the conclusion that the original locality was situated in the Indian Ocean. As stated above, Mr. Stanley Gardiner's specimens were obtained from a depth of 45 fathoms and in a living state. It would be extremely interesting if light could be thrown upon the following questions concerning Decaisne's type and the specimen in Herb. Chauvin. Did they both come from the same locality? Were they collected by Du Petit Thouars? From what island or coast did they come? And from what depth were they obtained? If the species is of restricted distribution, and occurs only at so great a depth as 45 fathoms, the explanation of its being so scantily represented—namely, in only two herbaria—is obvious.

The thallus of *Udotea* consists, as is well known, of unicellular, dichotomously branched filaments, which in some species are simple, as in *U. conglutinata*, and in others bear numerous short lateral branchlets varying in form according to the species. *U. palmetta* is one of the group characterised by bearing these lateral branchlets, and they are of the simpler type, being short, undivided, or more or less forked, and borne now along one side, now along the other side, of the same main filament, but never on both sides at once. They are not sufficiently large to form a cortex like that

which conceals the main filaments in *Udotea argentea*, Zan., and other species, but they can be detected by a lens as standing out along the main filaments even before the plant, whether dry or moist, has been decalcified. In Decaisne's type the branchlets are more short and simple than in Chauvin's specimen, where each lateral branchlet frequently divides into two or three points. The plants from Cargados Carajos resemble the type in this character, and have mostly simple, short, pointed branchlets.

26. Udotea argentea, Zanard. Plant. Mar. Rub. in Mem. R. Ist. Ven. vol. vii. (1858) p. 290, tab. 10. figs. 1 *a*, 1 *b*.

f. typica, form. nov.; ramulis lateralibus capitatis; capitibus varie angulatis aut lobatis.

Coetivy, on reefs exposed at dead low tide. Cargados Carajos, 22, 30, and 47 fms.

Geogr. Distr. Red Sea.

This species is not a well-known one, but it is so well marked that, when once recognised, it is quite unmistakable. The figures given by Zanardini (*l. c.*) of the original plant, collected by Portier at Suez, are quite sufficiently good to identify this characteristic species, even despite the loss of Zanardini's type, which has been searched for in foreign herbaria in vain. In habit *U. argentea* is often repeatedly proliferous, the proliferations overlapping each other so thickly at times that a single plant forms a sort of fan-shaped colony. The structure is, generally speaking, like that of other corticated species of *Udotea*, but it is distinguished from all of them by the character of the lateral branchlets. In *U. argentea* these arise at short intervals in two or three rows along the main filaments and bear each a head which is variously angulate or lobed. These capitate lateral branchlets soldered together by a deposited cement of calcium carbonate form a strong cortex, and thus unite into a firm frond the parallel main filaments, which form the framework of the thallus. The variations in the form of the head of the lateral branchlets are sufficiently marked to allow of the species being divided up into several forms, which appear to have also a more or less definite geographical distribution. The form represented in the present collection is the one which we regard as a typical representative of the original plant from the Red Sea, and we call it therefore f. *typica*. Other forms will be described and figured by us in our account of the *Udoteæ* collected by Madame Weber van Bosse during the 'Siboga' Expedition.

Since the above remarks were written, we have recently had the great satisfaction of examining what we had long desired to see, namely, specimens of *U. argentea* from the Red Sea, and actually from the type-locality. These were included among some unnamed specimens submitted to us by Prof. R. J. Harvey Gibson and had been collected by Mr. C. Crossland at Suez Bay. They have since been embodied in Prof. Gibson's paper read before the Linnean Society on December 5th, 1907. Mr. Crossland's specimens supply just the geographical link which we desired for the completion of the chain of proof that we had rightly referred the Indian Ocean specimens to the *U. argentea*, which had previously been recorded only from the Red Sea. The Suez Bay specimens exactly resemble those of Mr. J. Stanley Gardiner, while further to the east, as shown by specimens from the Malay Archipelago ('Siboga'

Expedition, *Madame Weber*) and from Queensland (*Bailey*), the species exhibits slight modifications of internal structure; and, further, a slightly modified form occurs in the West Indies. These forms we hope to describe in a paper soon to be published.

CLADOCEPHALUS, Howe.

27. CLADOCEPHALUS EXCENTRICUS, sp. n. (Plate 23. figs. 14–17.)

Planta læte viridis, solitaria, usque ad 10 cm. alta, adspectu primo *Udoteam conglutinatam* simulans, stipite e substrato calcareo orto, simplici, olivaceo, usque ad 3 cm. alta, tereti, solido, 1–2 mm. crasso; fronde inæqualiter cyathiformi, peltata, late expansa, primo rotundata, demum irregulariter elliptica vel lobata, usque ad 10 cm. lata, membranacea, viridi, zonata; filamentis frondis primariis e stipite radiantibus, pallide viridibus, 25 μ crassis, superne in ramulos dense intertextos et corticem frondis formantes dichotome divisis, ramulis ultimis hyalinis 10 μ crassis.

Cargados Carajos, 30, 45, and 47 fms.

The genus *Cladocephalus* was founded by Mr. M. A. Howe (Bull. Torrey Bot. Club, xxxii. 1905. p. 569) on a new plant, *C. scoparius*, collected by him in the Bahamas. The characters by which the author distinguishes this genus from *Udotea*, its nearest ally, are the external habit and the intricate labyrinthiform nature of the pseudo-cortex (figs. 15, 16), which is composed of repeatedly divaricato-dichotomous filaments closely interwoven. The author describes it thus:—"The cortex is formed by branches originating subdichotomously from the more peripheral members of the medullary strand, and becoming afterwards apparently lateral. These branches then undergo repeated divaricate forkings, with a gradual diminution of diameter, until finally they may have only one-fifth or even one-twelfth the diameter of the filaments of the central strand." We find the same peculiar cortical structure in *Flabellaria luteo-fusca*, Crouan, from Guadeloupe; indeed a microscopical preparation of that species is quite indistinguishable from one of *Cladocephalus scoparius*, Howe. The only difference between the two species is in the habit and colour. *C. scoparius* is of a yellowish-brown, substramineous, or olivaceous colour on drying and has a scopiform or thamnioid capitulum, "varying in outline from elongate-fusiform or elongate-ellipsoid to obovoid or subspherical," while *F. luteo-fusca* has a cuneate-flabellate or spathulate frond, with a subentire to eroso-lacerate margin. The stem of *F. luteo-fusca* is sometimes branched, as is that of *C. scoparius*. *Cladocephalus* being now established as an independent genus, *F. luteo-fusca*, Crouan, must be transferred to it under the name of *Cladocephalus luteo-fuscus* *.

Crouan's species was published by Mazé and Schramm (Algues de la Guadeloupe, ed. ii. 1870–77, p. 88) without description. They say:—"Croît dans un fond de sable vaseux, entre des fragments de rochers et de madrépores brisés. . . . . Coloration brune noirâtre persistante. Saint Martin (Lac Simpson, près l'embarcadère de l'habitation Durat, Anse du Marigot). Presque toute l'année. Coll. nos. 1403, 1904." Consequently the species could not be recognised save by comparison with an authentic specimen.

* Since the present paper was read before the Society, Dr. F. Börgesen, having come to a similar conclusion about *F. luteo-fusca*, has transferred it to the genus *Cladocephalus* (Vidensk. Meddel. naturh. Foren. Kjöbenhavn, 1908, p. 44).

Authentic specimens of it are preserved in the British Museum, and we have figures and a diagnosis of them awaiting publication.

Since this note was written, an excellent diagnosis of *Flabellaria luteo-fusca*, Crouan, has been published by Mr. Howe (in Bull. Torrey Bot. Club, xxxiv. 1907, p. 513), who, presumably on the ground of external habit, follows Murray and Boodle (Journ. of Bot. xxvii. 1889, p. 239) and places it in *Udotea*.

Hitherto the only plants of either species of *Cladocephalus* have been recorded from the West Indies alone, but we now propose to describe a third species which was collected by Mr. Gardiner in the Indian Ocean. Among Mr. Gardiner's plants are several specimens which have all the appearance of a peltate *Udotea* (fig. 14), being green, zoned, and borne on a delicate stalk. An examination of their structure reveals, however, a labyrinthiform pseudo-cortex (figs. 15, 16) similar to that of *C. scoparius* and *C. luteo-fusca*. But while in these two latter species the lateral branchlets arise from a comparatively coarse main filament, 50 μ broad, in our Indian Ocean plant the main filaments are only 25 μ wide, and the contrast in size between them and the final dichotomies of the branchlets (fig. 16) is not nearly so marked as in the two other species. One of the most characteristic features of our plant is its peltate habit, resembling that of *Udotea conglutinata* f. *infundibuliformis* (*U. infundibulum*, J. Ag., and *U. cyathiformis*, Decne.); but in addition to having a very different structure, it is at once distinguished from that species in being uncalcified. The form of the cup is irregular, being lop-sided, much raised on one side and depressed on the other. The new species has a very slender stalk and a large frond, much in the proportion of *U. conglutinata*, whereas the two West Indian species have long thick stalks.

We would point out that in the generic description of *Cladocephalus* (*l. c.* p. 569) the author describes the capitulum as thamnioid or scopiform and non-zonate. These characters are, however, of specific rather than of generic value; and we propose that the generic diagnosis should be amended in such a way as to admit the inclusion of other species which possess the structural character of *Cladocephalus*, viz., the intricate labyrinthiform pseudo-cortex.

Avrainvillea, Decaisne.

28. Avrainvillea amadelpha, Gepp. (Plate 23. fig. 20; Plate 24. figs. 21, 22.)

Syn. *Udotea amadelpha*, Mont. in Ann. Sci. Nat. 4 sér. t. vii. (1857) p. 136; De Toni, Syll. Alg. i. (1889) p. 509.

Amirante, 30 fms. Coetivy, on reefs exposed at dead low tide. Saya de Malha, 25 and 29 fms. Cargados Carajos, 47 fms. Chagos Archipelago: Salomon, on reefs exposed at dead low tide.

Geogr. Distr. Western Indian Ocean.

This species was considered by its author to belong to *Udotea*, in which genus it has till now always been placed, but as a more or less unknown member. The original plant was collected by Le Duc at the Island of Galega in the Indian Ocean and was at some time divided, the larger part being preserved in the Decaisne Herbarium in Paris, while the smaller part found its way into Kützing's Herbarium, now in the possession

of Madame Weber van Bosse. By the kindness of M. Hariot and of Madame Weber we have seen and examined these two portions of the type, and we find that both in habit and structure it possesses the generic characters of *Avrainvillea* and not of *Udotea*. The filaments are uncalcified, branch dichotomously, bear no side branchlets, and are not parallel but are more or less intricated to form a feltwork as in all species of *Avrainvillea*. In almost all the species of *Udotea* the whole plant is generally more or less calcified, the main filaments run out almost parallel from the stipes to the periphery of the frond, bearing in many species lateral branchlets of peculiar form. We have therefore transferred *U. amadelpha*, Mont., to the genus *Avrainvillea*. In the original specimen many short thickish stalks spring from a thickened crowded base and generally branch dichotomously, each bearing a small rather thin frond, the whole plant being of a brownish colour and about 6 cm. high. The basal part has a more or less felt-like hairy appearance, caused by the projection beyond the surface of the ends of filaments composing the stem.

A. amadelpha has never been recorded since the original description was published, and we were therefore greatly interested to find specimens of it in the collections of Mr. Stanley Gardiner, who gathered it from reefs and deep water in five different localities more or less in the neighbourhood of Galega. Some of these plants are less congested in their habit of growth and attain larger dimensions, up to 17 or 18 cm. (the stalks themselves being about 6 cm., the height of the entire plant described by Montagne). These large plants all come from deep water, 25–47 fms., whereas the congested forms, which exactly resemble the type, were collected on reefs exposed at dead low water.

A. amadelpha is distinguished from other species of the genus by the peculiar form of the apices of the frond-filaments, which are torulose (fig. 19), sometimes irregularly swollen on one side, often twisted and curved and often so interwoven as to form a thin pseudo-cortex of the frond (fig. 20). The filaments do not, as a rule, diminish so markedly in width towards their apices as is the case in *A. lacerata*, to which species *A. amadelpha* is in structure closely allied.

29. Avrainvillea Gardineri, sp. n. (Plate 24. figs. 23, 24.)

Planta elata usque ad 30 cm. alta, solitaria; rhizomate crasso luride fusco, 9–12 cm. longo, 1·5 cm. crasso, e basi bulbosa suboblique adscendente, et in stipitem brevem compressum (1·5–2·5 cm. longum, 6–9 mm. latum) viridem apice subito mutato; fronde e olivaceo viridescente (nunquam brunneo) amplissima (usque ad 18 cm. alta et 20 cm. lata) rotundata, basi plerumque cordata vel auriculato-cordata, membranacea, zonata, margine primo integra, demum senectute plus minusve grosse lacerata; frondis filamentis laxe intertextis et facile separabilibus, 20–30 μ crassis, apices versus haud attenuatis, plerumque regulariter torulosis, ad apices interdum leviter tortuosis sed inter sese vix intertextis.

Cargados Carajos, 22, 30, and 47 fms.

This species is a deep-water form and one of the largest members of the genus so far as we know it, rivalling *A. nigricans*, Decne., the biggest species of the West Indies, and

is indeed a very handsome plant. The rhizome is cylindrical, is of considerable size, and is often encrusted with epiphytic animals; it arises obliquely or subvertically from the bulbous base by which the plant is attached. It rather suggests that the plant grew on a firm matrix covered with three or four inches of mud; and at its apex it is abruptly transformed into a short flattened green stalk, which bears the large round subauriculate membranaceous frond. The frond being thin shows clearly, when held up to the light, the zonate marking. When young and small the frond is quite entire; but in the old plants it is sometimes split here and there along the radii, so that it appears deeply and irregularly lacerate. The colour varies from a deep olive to a light green, while the rhizome is pale brown. In young fronds the base is rather cuneate, while in older plants it is often auriculate-cordate.

The filaments of the frond are markedly torulose for some distance behind the apex (fig. 22), and do not taper towards their apices; the apices are often curled, but not markedly interwoven.

A near ally to this species is *Avrainvillea nigricans*, Decne., from which it differs in having a short flattened stipes on a long unbranched rhizome and also a very thin green frond; its frond-filaments are of fairly uniform thickness (20–30 μ diam.) and are much smaller than those of *A. nigricans*, which measure 60 μ or more inside the frond, but diminish to 30 μ at their apices. Further, *A. Gardineri* is confined to the western Indian Ocean, being known only from Cargados Carajos, whereas *A. nigricans* is a West Indian species.

A. Gardineri resembles *A. amadelpha* in being composed of filaments which for a certain distance behind the apex are torulose, but in *A. Gardineri* the torulose beading is more regular, extends further back from the apices of the filaments, and the filaments are wider than those of *A. amadelpha*. The pseudo-cortex, composed of twisted knotted apices, usually characteristic of *A. amadelpha* is not found in *A. Gardineri*, though in the latter species the torulose apices are often curled and loosely intertwined. In habit *A. Gardineri* and *A. amadelpha* are quite distinct.

CHLORODESMIS, Bail. et Harv.

30. CHLORODESMIS COMOSA, Bail. et Harv. in Harvey, Nereis Bor.-Amer. iii. p. 29 (1858).

Avrainvillea comosa, G. Murr. & Boodle, in Journ. of Bot. xxvii. 1889, p. 71, tab. 282. fig. 12; De Toni, Syll. Alg. i. 1889, p. 515.

Hab. Seychelles: Praslin, on reef.

Geogr. Distr. Fiji, Friendly Islands, New Caledonia, New Guinea, Celebes.

HALIMEDA, Lamour.

31. HALIMEDA TUNA, Lamour. Classif. Polyp. corall. (1812) p. 186; E. S. Barton, Siboga-Expeditie, Monographe lx. *Halimeda*, 1901, p. 11, t. 1.

f. TYPICA, E. S. Bart., Coetivy reef. Saya de Malha, 26 and 55 fms. Cargados Carajos, 30, 45, and 47 fms. Chagos Archipelago: Egmont, lagoon shoal and reef.

f. TYPICA, E. S. Bart., varying to f. PLATYDISCA, E. S. Bart., Cargados Carajos, 47 fms.

f. PLATYDISCA, E. S. Bart., Amirante, below 20 and 25 fms. Seychelles, below 34 and 44 fms. Saya de Malha, 26 fms. Cargados Carajos, 30, 45, and 47 fms.

Geogr. Distr. Mediterranean. Atlantic. Indian Ocean. Pacific.

32. HALIMEDA CUNEATA, Hering, in Flora, xxix. (1846) p. 214; E. S. Bart. Siboga-Expeditie, Mon. lx. *Halimeda*, p. 15, t. 1.

f. UNDULATA, E. S. Bart., Chagos Archipelago: Coin, Peros, and Salomon, on reefs exposed at dead low tides.

Geogr. Distr. Indian Ocean. Pacific.

These specimens have the habit of f. *undulata*, with the undulate and thickened margin, and have also the thickened junction of filaments at the apex of each joint, but the lateral walls of the peripheral cells are not connected for more than a quarter of their length, and in some cases hardly so much.

33. H. OPUNTIA, Lamour. *l. c.* p. 186; E. S. Bart. *l. c.* p. 18, t. 2.

f. TYPICA, E. S. Bart., Amirante, below 20 fms., below 25 fms., 30–100 fms. Seychelles, 34 fms. Saya de Malha, 25, 26, 29, and 55 fms. Cargados Carajos, 30 fms. Chagos Archipelago: Salomon reef, Coin, Peros reef, Chagos 30 fms., Diego Garcia reef.

f. TYPICA, E. S. Bart., varying to CORDATA, E. S. Bart., Amirante, 25 fms. Cargados Carajos, 30 fms. Chagos Archipelago: Salomon reef.

f. TYPICA, E. S. Bart., verging to TRILOBA, E. S. Bart., Salomon reef.

f. TYPICA, verging to CORDATA and TRILOBA, Diego Garcia reef.

f. CORDATA, E. S. Bart., Amirante, 20 and 30 fms. Coetivy reef. Seychelles, 34 fms. Saya de Malha, 26 and 29 fms. Salomon reef.

Geogr. Distr. Atlantic. Indian Ocean. Pacific.

34. H. GRACILIS, Harvey, ex J. Ag. Till Alg. Syst. viii. (1887) p. 82; E. S. Bart. *l. c.* p. 22, t. 3.

f. TYPICA, E. S. Bart., Amirante, below 20 fms. and below 25 fms. Saya de Malha, 25 and 29 fms.

Geogr. Distr. Atlantic. Indian Ocean. Pacific.

35. H. INCRASSATA, Lamour. *l. c.* p. 186; E. S. Bart. *l. c.* p. 25, t. 4.

f. TYPICA, E. S. Bart. (with rather small joints). Chagos Archipelago: Coin, Peros, reef. Egmont.

f. MONILIS, E. S. Bart., Amirante, 25 fms. Coetivy reef. Saya de Malha, 25 fms. (between *typica* and *monilis*). Cargados Carajos, 47 fms.

f. OVATA, J. Ag., Seychelles: Praslin reef. Amirante, 44–20 fms. Saya de Malha, 26 fms. Cargados Carajos, 30 fms. Chagos Archipelago: Salomon reef; Egmont reef and lagoon shoal.

Geogr. Distr. Atlantic. Indian Ocean. Pacific.

36. HALIMEDA MACROLOBA, Decne. in Arch. Mus. Hist. Nat. Paris, t. ii. (1841) p. 118; E. S. Bart. Siboga-Expeditie, Mon. lx. *Halimeda*, p. 24, t. 3.

Seychelles: Praslin reef.

Geogr. Distr. Indian Ocean. Pacific.

PHÆOPHYCEÆ.

FUCACEÆ.

SARGASSUM, Ag.

37. SARGASSUM DUPLICATUM, J. Ag. Sp. Sarg. Austral. (1889) p. 90; De Toni, Syll. Alg. iii. (1895) p. 50.

Seychelles: Praslin, on reefs exposed at dead low tide.

Geogr. Distr. Indian Ocean. South Pacific.

38. S. SUBREPANDUM, Ag. Sp. Alg. i. (1823) p. 8; J. Ag. Sp. Sarg. Austral. (1889) p. 95; De Toni, Syll. Alg. iii. (1895) p. 62.

Seychelles: Praslin, on reefs exposed at dead low tide.

Geogr. Distr. Indian Ocean. Red Sea.

This species is represented by several specimens showing slight variation in the form of the leaves.

39. S. PERSICUM, Kütz. Spec. Alg. (1849) p. 610 and Tab. Phyc. xi. (1861) tab. 13; De Toni, Syll. Alg. iii. (1895) p. 114.

Seychelles: Praslin, on reefs exposed at dead low tide.

Geogr. Distr. Persian Gulf.

This species is represented in the collection by one plant only, which is clearly the same as that figured in Kützing's Tab. Phyc. xi. t. 13. It seems to be closely allied to *S. vulgare*. Our plant is also exactly like a specimen in Herb. Kew, placed under the name *Sargassum vulgare* and labelled "Th. Kotschy, Pl. Pers. austr. Ed. R. F. Hohenacker, 1845. No. 30^5. *Sargassum vulgare* var. *latifolium*, Endl. et Dies.—Dies. Ad oram Karek, insulæ sinus Persici. M. Jan. 1841."

TURBINARIA, Lamour.

40. TURBINARIA CONOIDES, Kütz. Tab. Phyc. x. (1860) p. 24, tab. 66; E. S. Bart. in Trans. Linn. Soc., 2nd ser. Bot. vol. iii. (1891) p. 217; De Toni, Syll. Alg. iii. (1895) p. 126.

Seychelles: Praslin, on reefs exposed at dead low tide.

Geogr. Distr. Kamschatka. Indian Ocean. Red Sea. Shores of North Australia.

Var. EVESICULOSA, E. S. Bart. *l. c.* p. 217.

Coetivy, on reefs exposed at dead low tide.

Geogr. Distr. Malay Archipelago.

41. TURBINARIA DECURRENS, Bory, Voy. Coquille, Bot. i. (1826–8) p. 119; E. S. Bart. Siboga-Expeditie, Mon. lx. *Halimeda*, p. 217.

Seychelles: Praslin, on reefs exposed at dead low tide.

Geogr. Distr. Red Sea. Indian Ocean. China Sea.

42. T. MURRAYANA, E. S. Bart. in Trans. Linn. Soc., 2nd ser. Bot. vol. iii. (1891) p. 218, tab. 54. fig. 2; De Toni, Syll. Alg. iii. (1895) p. 127. (Plate 24. figs. 25, 26.)

Seychelles; Praslin, on reefs exposed at dead low tide.

Geogr. Distr. Macassar. New Guinea.

The only specimens of this alga hitherto seen by the authors have consisted solely of the cone of so-called "leaves" and receptacles characteristic of an ordinary *Turbinaria* plant. In the present collection of Mr. Gardiner there is, however, material of *T. Murrayana* which adds considerably to our knowledge of its manner of development and growth. The material in question consists of colonies of plants in various stages. The mature "leaves" of the typical *T. Murrayana* are solid (not hollow), winged and slightly toothed both along the wings and the margin of the leaf; and being short-stalked and closely-set they make a cone-like head, short and compact. At the base of the main stem, close above the point of attachment to the substratum, there arise in the place of leaves for about 1 cm. up the stem a number of cylindrical, much and irregularly branched, filiform outgrowths often arranged in alternating verticils of three, spreading in all directions and varying in length (fig. 23). These are the "Langtriebe" of Engler and Prantl and are figured by Kützing for some of the species in his Tab. Phyc. vol. x. tabb. 66–68. If these branched outgrowths are examined it will be seen that they are really stolons, which run out in all directions horizontally and that some of them sprout at their apices into small plantlets, after becoming attached to a shell or other convenient substatum. From the new base arises an upright shoot which puts out near the base a few filamentous branches (potential stolons) and above them produces 3–5 simplified leaves (fig. 24) quite different from the well-known trigonous "leaves" of the coma of the mature plant. They are shortly stalked, flat, cuneate at base, lanceolate, longly acuminate, and about 1–2 cm. long, sinuato-denticulate at the margin and slightly carinately thickened beneath, and bear cryptostomata; but each new leaf is shorter and broader than the last and approximates more and more to the typical generic form, till in the centre of a sort of basal rosette of 4–5 of these flat lower leaves of gradually decreasing length there is seen a small peltate trigonous leaf of the usual type (fig. 24, *a*, *b*). The shoot continues to grow, the early acuminate leaves fall off, and the ordinary mature plant of *T. Murrayana* remains as figured (*l. c.* tab. 54. fig. 2).

43. T. ORNATA, J. Ag. Sp. i. (1823) p. 266; E. S. Bart. *l. c.* p. 219. (Plate 24. fig. 27.)

Seychelles: Coetivy. Chagos Archipelago: Diego Garcia. On reefs exposed at dead low tide.

Geogr. Distr. N. & S. Pacific. Indian Ocean. Australia.

The manner of propagation described above for *T. Murrayana* occurs also in some of the specimens of *T. ornata* brought by Mr. Gardiner from both the Seychelles and the

Chagos Archipelago. Stolons emerge from the base of the stem, but in *Turbinaria ornata* they are somewhat flattened or sometimes bluntly triquetrous, not cylindrical as in *T. Murrayana*. From these stolons arise young plantlets less regular in habit than those of *T. Murrayana*, and consisting of only one or two straggling linear-lanceolate grossly serrate first leaves (fig. 27), which are abruptly succeeded without any transitional stages by the normal trigonous leaves of the genus, though leaves with the specific character of a double row of teeth do not appear till later. Another noteworthy feature of *T. ornata* is that the stolons are apparently not confined to the base of the mature plant; for similar outgrowths often arise from the receptacular branches, either together with or in the place of the fertile branches.

We would here insert a note about *Turbinaria dentata*, Bart., and its identity with *T. condensata*, Sond.

In 1891 one of us published a new species of *Turbinaria*, *T. dentata* (Trans. Linn. Soc. ser. 2, Bot. iii. (1891) p. 219, pl. 54. fig. 5), founded on a specimen collected at Macassar by Madame Weber van Bosse. The distinguishing feature of this species was the small leaf crowned by sharp teeth, which extend down the angles of the vesicle. In the same paper, *T. condensata*, Sond., was mentioned (*l. c.* p. 220), and as the species was unknown to the author, she contented herself with transcribing the original diagnosis (Kütz. Tab. Phyc. x. 1860, p. 25). Figures of *T. condensata*, natural size, and of an enlarged vesicle crowned with teeth are given (*l. c.* tab. 69. figs. 2, 3); but in the absence of an authentic specimen of *T. condensata* the author did not regard that species as identical with her *T. dentata*, as there seemed to be some slight differences between her plant and the Kützing figure. Some time ago, however, Major Reinbold was so kind as to send to the author part of Sonder's original specimen of *T. condensata*, and at once it became evident that that species and *T. dentata*, E. S. Bart., are identical. The only difference between them is that in the Macassar plant the teeth are found regularly marking the angles of the vesicles, whereas in *T. condensata* the teeth are often confined to the crown at the top. This difference, however, amounts to nothing, and we therefore annul *T. dentata*, E. S. Bart., which must now be ranked as a mere synonym of *T. condensata*, Sond.

Zonaria, J. Ag.

44. Zonaria variegata, Mart. in Mart. Icon. Crypt. tab. 2. fig. 2; Sauvageau, in Soc. Sc. d'Arcachon Stat. Biol. Trav. Lab. viii. (1904–5) Paris, 1905, pp. 66–81.

Syn. *Gymnosorus variegatus*, J. Ag. Anal. Alg. cont. i. (1894) p. 11; De Toni, Syll. Alg. iii. p. 227 (1895).

Ralfsia ceylanica, Harv. ex Gepp, in Journ. Linn. Soc., Bot. xxxv. (1903) p. 477, tab. 13. figs. 1–4.

Zonaria Isselii, Piccone & Grunow, in Nuov. Giorn. Bot. Ital. xvi. (1884) p. 297, tab. 7. figs. 1–4, tab. 9. fig. 1.

Coetivy, on reef, and at 32 feet obtained by diver. Saya de Malha, 26 fms. Chagos Archipelago: Salomon reef; Egmont reef; Diego Garcia lagoon.

Geogr. Distr. N. & S. Atlantic. Pacific. Indian Ocean.

An interesting account of this species is given by Sauvageau (Biol. Trav. Lab. viii. pp. 66–81), to which our attention was drawn by Madame Weber van Bosse. The author there points out sundry errors made by J. G. Agardh in his 'Analecta Algologica,' continuatio i. (1894) p. 11, in describing his new genus *Gymnosorus*, which is founded on the present species. J. G. Agardh separates *Gymnosorus* from *Zonaria* in the belief that the former possesses neither indusium nor paraphyses. Sauvageau, however, and, before him, H. M. Richards have seen the indusium, which Sauvageau describes in detail; and as regards the paraphyses he observed peculiar bodies which, though not typical paraphyses, are at least comparable with them. It is therefore obvious that the type of *Gymnosorus* must be excluded from that genus; that is, *Zonaria variegata* resumes its old position. Sauvageau has closely studied the plant in the Canaries, and describes the manner in which the erect thallus grows out from the horizontal or creeping thallus, and points out its preference for shallow rock-pools, where it can creep over submerged surfaces near the brink of the pool. The normal form of the plant is the creeping rooting thallus; and the erect form is only found when some marginal part or parts of the growing thallus fail to find a suitable substratum to which they may attach themselves, and accordingly remain free, finally, after the death of the older creeping parts, assuming the appearance of an erect plant with a comparatively small base.

The creeping vegetative thallus is figured in the account of the Marine Algæ collected at the Maldive and Laccadive Islands by Mr. Stanley Gardiner, in Journ. Linn. Soc., Bot. xxxv. (1903) tab. 13. figs. 1–4, under the name *Ralfsia ceylanica*, Harv. This plant, previously undescribed, is, as we now see, nothing but a typical form of *Zonaria variegata*.

PADINA, Adans.

45. PADINA COMMERSONII, Bory, Voy. 'Coquille,' Bot. i. (1826–8) p. 144, tab. 21. fig. 2; De Toni, Syll. Alg. iii. (1895) p. 244.

Seychelles: Praslin, on reefs exposed at dead low tide.

Geogr. Distr. West Indies. Indian and Pacific Oceans.

46. P. DISTROMATICA, Hauck, in Hedwigia, xxvi. (1887) p. 43; De Toni, Syll. Alg. iii. (1895) p. 244.

Seychelles, on reefs exposed at dead low tide.

Geogr. Distr. Somali coast.

HALISERIS, Targ.-Tozz.

47. HALISERIS WOODWARDIA, J. Ag. Spec. i. (1848) p. 116; De Toni, Syll. Alg. iii. (1895) p. 254.

Seychelles, 44 fms.; Praslin reef. Amirante, below 20 fms.

Geogr. Distr. Australia. Sarawak. China Sea.

DICTYOTA, Lamour.

48. DICTYOTA DICHOTOMA, Lamour. in Desv. Journ. de Bot. ii. (1809) p. 42.

Amirante, below 25 fms., and 20–25 fms. Seychelles, 44 fms.; Praslin, on reefs exposed at dead low tide.

Geogr. Distr. Mediterranean. Atlantic. Pacific. Indian Ocean.

ECTOCARPUS, Lyngb.

49. ECTOCARPUS SPONGIOSUS, Dickie, in Journ. Linn. Soc., Bot. vol. xiv. (1875) p. 191; Gepp, in Journ. Linn. Soc., Bot. vol. xxxv. (1903) pp. 479–80, pl. 13. figs. 9–13.

Praslin, on reefs exposed at dead low tide.

Geogr. Distr. Indian Ocean: Mauritius, Laccadive Islands, Admiralty Islands, Cheduba Straits (Burmah).

APPENDIX.

With the Algæ were a few marine phanerogamic plants, the names and distribution of which are as follows. We have to thank Dr. A. B. Rendle for assisting us in the determination of them.

POTAMOGETONACEÆ.

ZOSTERA, Linn.

50. ZOSTERA NANA, Roth, Enum. Pl. Germ. i. (1827) p. 8.

Imperfect specimen, doubtfully referred here.

Seychelles: Praslin. On reefs exposed at dead low tide.

Gen. Distr. N. & S. Atlantic (eastern shores). Mediterranean. Indian Ocean (western shores).

CYMODOCEA, Koenig.

51. CYMODOCEA SERRULATA, Aschers. & Magn. in Sitzber. Ges. naturf. Freunde Berlin, 1870, p. 84.

Seychelles: Praslin. On reefs exposed at dead low tide.

Gen. Distr. Red Sea. Indian and West Pacific Oceans. Mostly tropical.

52. C. ISOETIFOLIA, Aschers. in *op. cit.* 1867, p. 3.

Seychelles: Praslin. On reefs exposed at dead low tide.

Gen. Distr. Red Sea. Indian and Pacific Oceans. Mostly tropical.

53. C. CILIATA, Ehrb. ex Aschers. in *loc. cit.*

Amirante, 25 fms. Coetivy, on reef. Cargados Carajos.

Gen. Distr. Red Sea. Indian and West Pacific Oceans. Mostly tropical.

Hydrocharidaceæ.

Halophila, Du Petit Thouars.

54. Halophila ovalis, Hook. f. Fl. Tasman. ii. (1860) p. 45.
Amirante, 20–25 fms. Seychelles, below 34 fms. Cargados Carajos, 30 fms.
Gen. Distr. Red Sea. Indian and Pacific Oceans.

55. Enhalus acoroides, Steud. Nomencl. Bot. ed. ii. (1840) p. 554.
Seychelles: Praslin. On reefs exposed at dead low tide.
Gen. Distr. Red Sea. Indian and West Pacific Oceans. Tropical.

EXPLANATION OF THE PLATES.

Plates 22–24.

Microdictyon pseudohapteron, sp. n.

Fig. 1. Plant, somewhat torn. (Nat. size.)

Fig. 2. Portion of thallus, showing (*a*) the stellate mode of branching of the filaments in one plane, and (*b*) the gradual tendency of the branchlets to fill in the meshes of the reticulum (× 8); *c* and *d*, enlarged diagrams of a cruciate and of a stellate node (× 20).

Fig. 3. Tenacula which hold the reticulum together. They are expanded crenellated end-walls of the branchlet, and are not special cells cut off by a transverse wall, as in *Struvea*. One (*a*) is detached, the other (*b*) is applied to the side of another cell. (× 75.)

Fig. 4. Rhizoids which attach the thallus to the substratum. They are thin unsegmented tubes arising from any point of the thallus cells and terminating in a nodulose expansion. *a.* A group of cells with rhizoids in various stages of development (× 40). *b.* Single rhizoid (× 110).

Struvea Gardineri, sp. n.

Fig. 5. Young plant showing main filament branched above by usually cruciate ramification in one plane into a reticulate frond with margin entire. (Nat. size.)

Struvea orientalis, sp. n.

Fig. 6. Plants showing habit, size, branching of main filament. *a.* Dried specimen. *b.* Specimen preserved in formalin. (Nat. size.) The stipes in figs. 5 and 6 is non-septate.

Fig. 7. Portion of frond showing (*a*) free edge composed of projecting branchlets, and (*b*) inner part of reticulum in which the primary meshes are much filled in by subsequently formed branchlets. (× 8.)

Fig. 8. Cells of frond enlarged. *a.* A primary mesh of the reticulum completely filled in by a subsequent growth of branchlet-cells. *b.* A few branching cells with a tenaculum. (× 25.)

Fig. 9. Tenacula or specialised terminal cells which fasten the filaments of the reticulum together. (× 110.)

Bryopsis indica, sp. n.

Fig. 10. Habit of plant, simple and branched. (Nat. size.)

Fig. 11. Portion of plume showing arrangement of the ramuli alternately disposed in two double rows on opposite sides of the main filament. (× 75.)

Caulerpa cupressoides var. *typica* forma *Gardineri*, f. n.

Fig. 12. Habit of plant (dried specimen), showing minute distichous pinnules. (Nat. size.)

Fig. 13. Habit of plant (specimen preserved in formalin), showing minute tristichous pinnules. (Nat. size.) Figs. 12 and 13 are from drawings supplied by Madame Weber von Bosse.

Cladocephalus excentricus, sp. n.

Fig. 14. Habit of plant: *a*, in surface view, seen from above; *b*, in side view. (Nat. size.) By an error the stipes in fig. 14 *a* is erroneously shown as if visible through the frond.

Fig. 15. External view of frond showing the labyrinthiform pseudo-cortex, composed of repeatedly divaricato-dichotomous filaments closely interwoven. (× 280.)

Fig. 16. Single lateral mature branch arising from a main filament, constricted near the base and showing the divaricato-dichotomous system of branches which interlocking with their fellows form the labyrinthiform pseudo-cortex. (× 230.)

Fig. 17. Main filaments of frond near apex, showing young lateral branches in various early stages of the division shown in the preceding figure. (× 230.)

Tydemania expeditionis, Weber van Bosse.

Fig. 18. Creeping flabellate form of the plant; portion of the ramified non-septate axis, cylindric below, torulose above, and bearing about a dozen flabella. (× 3.)

Fig. 19. A torulose branch of the axis bearing a mature flabellum, the upper half of which has been cut away. At the apex of the continuation of the branch is a young flabellum in the first stages of development. (× 16.)

Avrainvillea amadelpha, A. & E. S. Gepp.

Fig. 20. Habit of mature plant, deep-water form, Saya de Malha, 29 fms. (Nat. size.)

Fig. 21. Filament of frond, cylindrical below, torulose and tortuous at apices. (× 110.)

Fig. 22. External view of frond showing the pseudo-cortex, composed of the interwoven torulose apices of the frond filaments. (× 280.)

Avrainvillea Gardineri, sp. n.

Fig. 23. Habit of mature plant, showing long unbranched rhizome, short stipes, and large thin zonate lacerate frond. (½ nat. size.)

Fig. 24. Filament of frond, more or less torulose for a considerable distance behind the apex, and not attenuated towards apex. (× 110.)

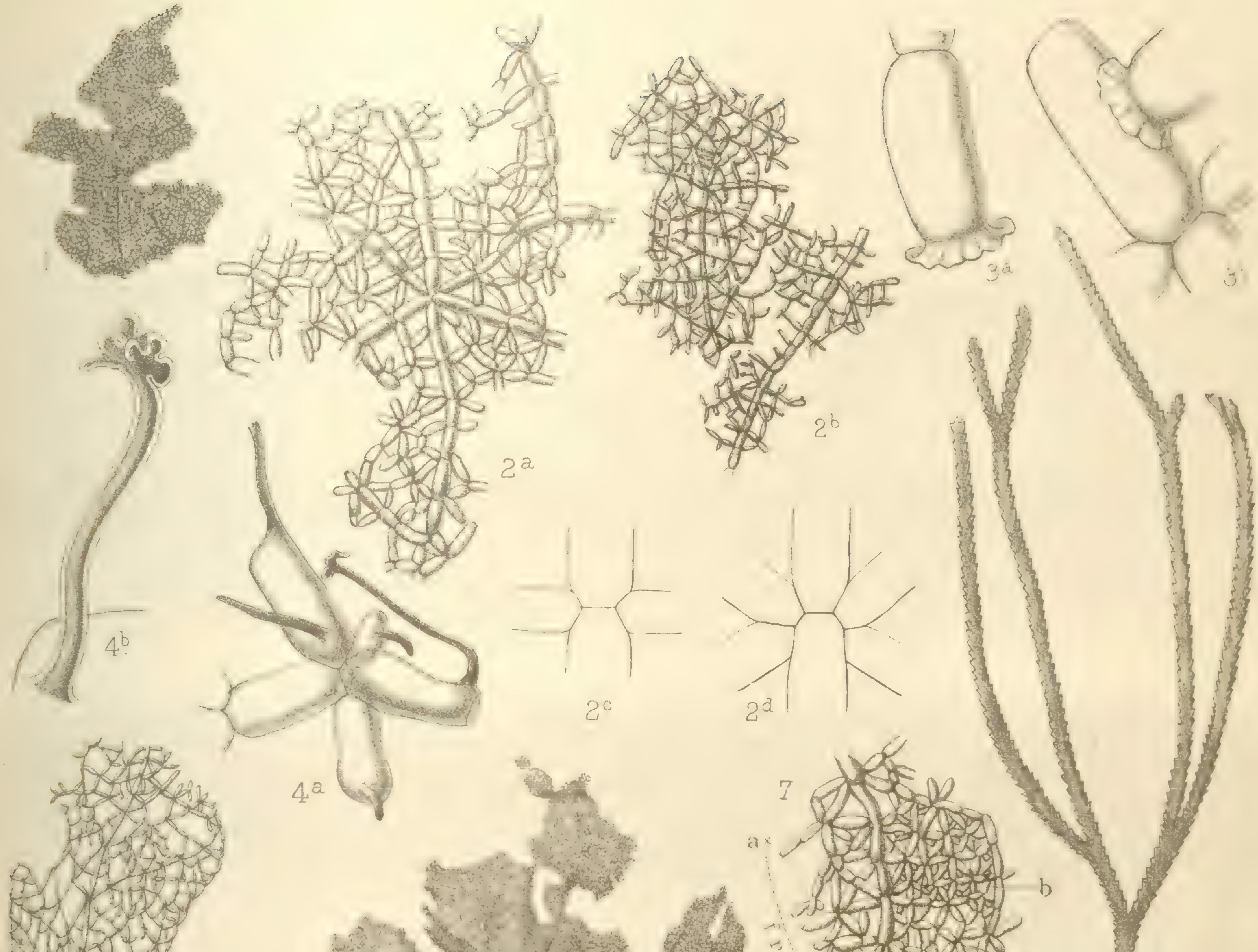
Turbinaria Murrayana, Bart.

Fig. 25. Mature plant, showing typical cone of solid trigonous leaves above, and numerous stolons below, one of which has already produced a bud (*a*). (Nat. size.)

Fig. 26. Young plants arising from stolons. *a*. Seen from above, showing rosette of primitive leaves, shortly stalked, flat, cuneate at base, the oldest being lanceolate and longly acuminate, each subsequent leaf approximating gradually to the typical trigonous normal leaves, of which two small ones are seen in the middle. *b*. A similar young plant, in side view. (Nat. size.)

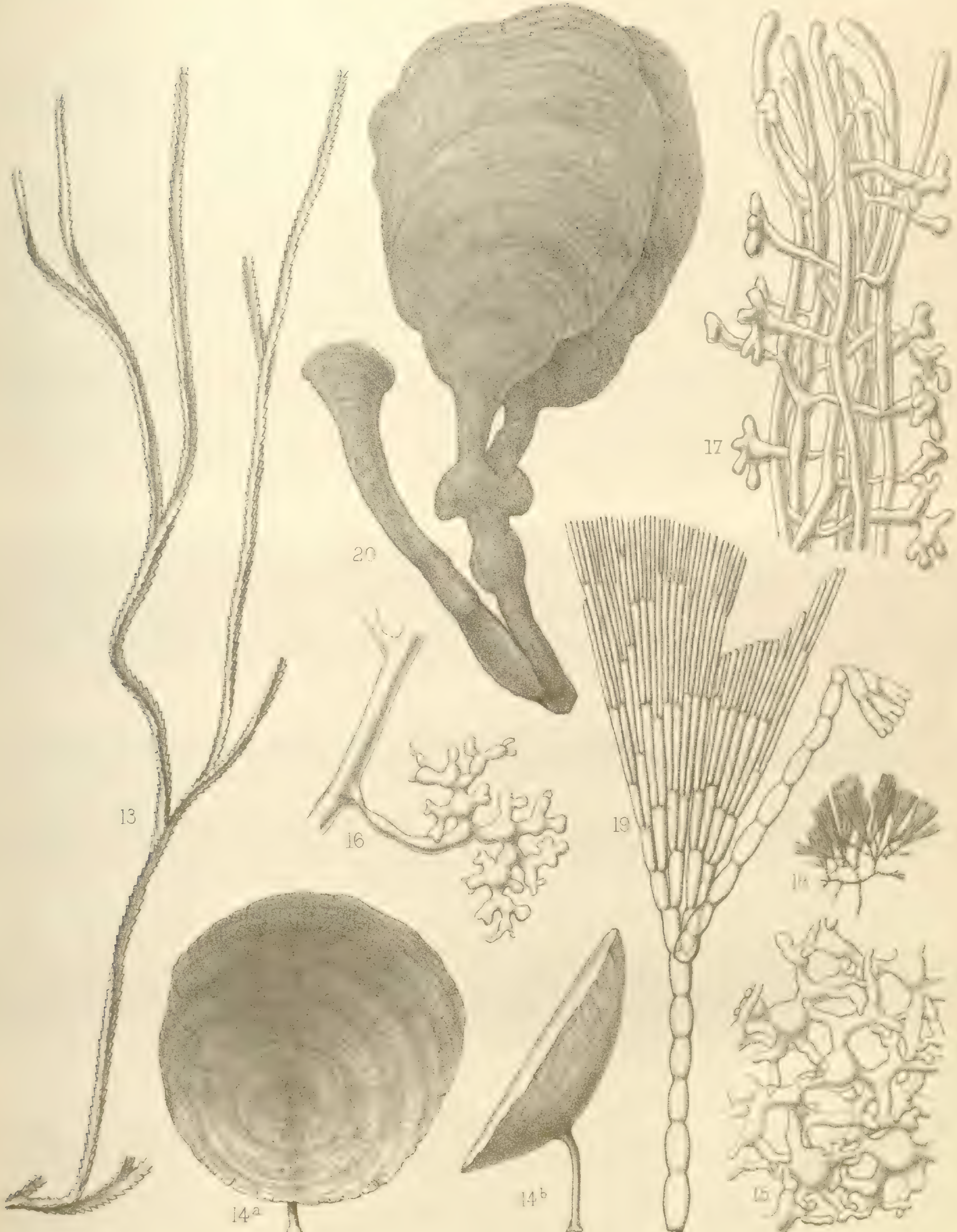
Turbinaria ornata, J. Ag.

Fig. 27. Young plants which have arisen from stolons, showing one or two primitive lanceolate leaves which are more serrate than the primitive leaves of *T. Murrayana*, Bart. (Nat. size.)



Highley del. et lith. Pitcher imp.

MARINE ALGAE FROM THE INDIAN OCEAN.



P. Highley del. et lith.

Pitcher imp.

MARINE ALGAE FROM THE INDIAN OCEAN.

P Highley del et lith.
Pitcher imp

MARINE ALGAE FROM THE INDIAN OCEAN.

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s*. to the public, and 6*s*. to Fellows; to Vols. 26–30, 4*s*. to the public, and 3*s*. to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

Second Series.—Botany.

Volume.		When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
I.	Part I.	1875.	0	8	0	0	6	0
	Part II.	1875.	0	16	0	0	12	0
	Part III.	1876.	0	12	0	0	9	0
	Part IV.	1876.	0	10	0	0	7	6
	Part V.	1878.	1	4	0	0	18	0
	Part VI.	1879.	1	6	0	0	19	6
	Part VII.	1880.	1	4	0	0	18	0
	Part VIII.	1880.	1	1	0	0	16	0
	Part IX.	1880.	1	0	0	0	15	0
II.	Part I.	1881.	0	12	0	0	9	0
	Part II.	1882.	0	5	0	0	3	9
	Part III.	1883.	0	10	0	0	7	6
	Part IV.	1883.	0	3	0	0	2	3
	Part V.	1883.	0	3	0	0	2	3
	Part VI.	1884.	0	13	6	0	10	0
	Part VII.	1884.	0	9	6	0	7	0
	Part VIII.	1884.	0	10	0	0	7	6
	Part IX.	1886.	0	7	0	0	5	0
	Part X.	1887.	0	3	4	0	2	6
	Part XI.	1886.	0	6	0	0	4	6
	Part XII.	1886.	0	8	0	0	6	0
	Part XIII.	1887.	1	7	0	1	0	0
	Part XIV.	1887.	0	7	0	0	5	0
	Part XV.	1887.	0	10	0	0	7	6
	Part XVI.	1888.	0	2	6	0	2	0
III.	Part I.	1888.	3	12	0	2	14	0
	Part II.	1891.	0	5	0	0	3	9
	Part III.	1891.	0	7	0	0	5	0
	Part IV.	1891.	0	6	0	0	4	6
	Part V.	1891.	0	6	0	0	4	6
	Part VI.	1891.	0	3	6	0	2	8
	Part VII.	1892.	0	6	0	0	4	6
	Part VIII.	1893.	0	6	0	0	4	6
	Part IX.	1893.	1	8	0	1	1	0
	Part X.	1894.	0	10	0	0	7	6
	Part XI.	1894.	0	3	4	0	2	6
IV.	Part I.	1894.	1	0	0	0	15	0
	Part II.	1894.	2	0	0	1	10	0

Second Series.—Botany (*continued*).

Volume.		When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
IV.	Part III.	1895.	2	10	0	1	17	6
	Part IV.	1895.	0	3	4	0	2	6
V.	Part I.	1895.	0	9	0	0	6	9
	Part II.	1895.	0	12	0	0	9	0
	Part III.	1896.	0	6	0	0	4	6
	Part IV.	1896.	1	0	0	0	15	0
	Part V.	1896.	0	14	0	0	10	6
	Part VI.	1896.	0	4	0	0	3	0
	Part VII.	1897.	0	4	0	0	3	0
	Part VIII.	1897.	0	6	0	0	4	6
	Part IX.	1899.	0	12	0	0	9	0
	Part X.	1899.	0	6	0	0	4	6
	Part XI.	1899.	0	7	0	0	5	0
	Part XII.	1899.	0	12	0	0	9	0
	Part XIII.	1900.	0	1	6	0	1	2
	Part XIV.	1900.	0	3	0	0	2	3
	Part XV.	1901.	0	6	0	0	4	6
VI.	Part I.	1901.	1	10	0	1	2	6
	Part II.	1901.	0	6	0	0	4	6
	Part III.	1902.	0	18	0	0	13	6
	Part IV.	1903.	0	8	0	0	6	0
	Part V.	1903.	0	8	0	0	6	0
	Part VI.	1903.	0	12	0	0	9	0
	Part VII.	1904.	0	12	0	0	9	0
	Part VIII.	1904.	0	12	0	0	9	0
	Part IX.	1904.	0	7	0	0	5	3
	Part X.	1904.	0	14	0	0	10	6
	Part XI.	1905.	0	4	0	0	3	0
VII.	Part I.	1904.	0	5	0	0	3	9
	Part II.	1905.	0	6	0	0	4	6
	Part III.	1906.	0	3	0	0	2	3
	Part IV.	1906.	0	7	0	0	5	3
	Part V.	1907.	0	10	0	0	7	6
	Part VI.	1907.	0	4	0	0	3	0
	Part VII.	1907.	0	6	0	0	4	6
	Part VIII.	1908.	0	5	0	0	3	9
	Part IX.	1908.	0	2	6	0	2	0
	Part X.	1908.	0	7	0	0	5	3

2nd Ser. BOTANY.]

[VOL. VII. PART 11.

THE TRANSACTIONS OF THE LINNEAN SOCIETY OF LONDON.

THE ANATOMY OF SOME SAPOTACEOUS SEEDLINGS.

BY

WINIFRED SMITH, B.Sc., F.L.S.

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

February 1909.

XI. *The Anatomy of some Sapotaceous Seedlings.*

By WINIFRED SMITH, *B.Sc., F.L.S.*

(Plates 25 & 26.)

Read 2nd April, 1908.

IN seeking for the origin of the laticiferous tissue of the Sapotaceæ I have had occasion to examine a number of seeds and seedlings of that order.

As a general interest has of late been aroused in the anatomy of seedlings from the point of view of phylogeny, and as I have found the literature on the Sapotaceæ barren of information on the subject, it seemed useful to collect my observations on the anatomy of Sapotaceous seedlings at once, instead of waiting till the work on the order in general was brought to a conclusion. I was the more inclined to do this because the order shows several uncommon features. One of these is the exceptional mode of transition from root to stem; another is the presence of a swollen hypocotyl and of some other signs of a geophilous habit; and the last lies in an apparent lack of continuity in the different parts of the vascular system.

Some seedlings of *Payena Leerii*, *Palaquium petiolare* and *P.* sp., *Bassia longifolia* and *B. latifolia*, *Mimusops Schimperi* and *M. Kauki*, *Imbricaria coriacea*, *Chrysophyllum Roxburghii* and *C. olivæforme*, were collected in Ceylon by Dr. Fritsch. The other seedlings examined were germinated at Chelsea Physic Garden from seeds obtained from Barbados, Singapore, Ceylon, and Sydney. I take this opportunity of expressing my sincere thanks to Sir Daniel Morris and Dr. Fritsch, to Mr. Ridley, Dr. Willis, Mr. Wright, and to Mr. Maiden, for so kindly supplying me with the means to carry out this research. Seeds gathered as soon as ripe, naturally dried, and sent simply in cotton bags were the most successful; but many failed to germinate.

Dr. Fritsch's seedlings were fixed in alcohol. Other material has been fixed for the most part in chromo-acetic acid or in acetic alcohol, and stained with Bismarck brown, orange gentian, and gentian violet. Cedar-wood oil replaced xylol, as the latter dissolves the latex.

The seeds and seedlings examined belong to the following species:—

Payena Leerii. *Bassia longifolia.* *Bassia latifolia.* *Palaquium petiolare.* *Palaquium* sp.	Placed by Engler and Prantl in the group *Palaquieæ-Illipineæ.*
Chrysophyllum Cainito. *Chrysophyllum olivæforme.* *Chrysophyllum Roxburghii.*	Of the *Palaquieæ-Chrysophylleæ.*
Bumelia tenax. *Achras Sapota.*	Of the *Palaquieæ-Sideroxyleæ.*

Mimusops Elengi.
Mimusops Kauki.
Mimusops Schimperi.
Imbricaria coriacea.
} Of the *Mimusopeæ.*

I propose to take *Payena Leerii* as a type and describe and illustrate it with some fulness, and then to indicate in what points the other species agree with the type or depart from it.

Payena Leerii has a large seed, measuring 27 mm. in length, 9 mm. in greatest width, and 7 mm. in greatest thickness. Its horny testa encloses a bulky endosperm, which covers the embryo completely except the tip of the radicle, which projects about a millimetre. The cotyledons are flat and about 0·6 mm. thick; they contain abundance of an oily substance. The endosperm is packed with starch. The plumular bud is represented only by a tiny cone of meristemmatic tissue. The embryo is extraordinarily precocious in development and assists much in the interpretation of the seedling. This was the more convenient as none of the seeds of *Payena Leerii* germinated, and I had no seedling which measured less than 8 cm. from the cotyledonary node to the root-apex.

The future stele is represented in transverse section of the radicle by a rectangle with the corners cut off. The sides of this figure are formed of desmogen, easily recognizable by its small cells and deeply staining nuclei. At the corners are narrow tracheids which occupy the position of the protoxylems of the seedling. In a seed with radicle about 1·67 mm. long, the tracheids die out about ·67 mm. from the node; while the latex-cells die out nearly a millimetre lower. At the node, on each side of the narrow tracheids, larger xylem elements appear, the three groups forming a band across the corner of the rectangle. Diagonals joining the corners of this figure are inclined at an angle of 45° to the cotyledonary plane.

This position is the peculiarity of the Sapotaceæ and is known in few instances outside the order. It is maintained throughout the transition from root to hypocotyl and from hypocotyl to cotyledons (Pl. 25. figs. 2–8, Pl. 26. fig. 9). It constitutes an exception to the rule enunciated by Dangeard *:—"Le plan vertical médian des cotylédons correspond toujours à un faisceau vasculaire de la racine." Throughout her seedling research Miss Thomas † has found Dangeard's rule to hold good, except in the case of *Fagus* and *Quercus*. Nowhere do I find any other exception vouched for.

A *seedling* measuring 95 mm. from root-apex to cotyledonary node shows two large, expanded, epigeal cotyledons, sessile, and with the shoot between them still only represented by a cone of meristemmatic tissue (fig. 1). The lower 40 mm. of the root are of nearly uniform diameter. Above this the axis widens suddenly, maintains its increased girth for about 20 mm., and then resumes that of the lower portions. A transverse section of the root 13 mm. from the apex (82 mm. from the node) shows it to be tetrarch with a large pith (fig. 2). Each xylem group consists of a single radial file of elements, the smallest external. A little higher the radial file is double and soon the internal parts

* *Loc. cit.* p. 87 (*cf.* post, p. 199).

† *Loc. cit.* p. 77 (*cf.* post, p. 199).

widen till the group is pear-shaped (fig. 3). I use the word "group" advisedly, as it will be seen that it represents more than one bundle.

A band of phloem surrounds the rectangular stele; both it and the pericycle are interrupted by large-celled parenchyma opposite the protoxylems.

Corresponding with the zone of greater girth, the transverse section at 48 mm. below the node shows a sturdy band of secondary wood about six cells deep. The periphery of the pith has also become lignified, leaving a central thin-walled region about a third of its whole diameter (figs. 4 & 4 *a*).

The primary xylem groups have now widened by the addition of metaxylem elements on each side of them.

The secondary thickening dies out about 35 mm. below the node (fig. 5). This swollen zone appears to occur generally in this species and is seen elsewhere in the order.

Above this point the interest centres in the changes which take place in the primary xylem. The metaxylem forks into two groups, which are placed to right and left of the protoxylem and internal to the extremities of the four phloem-bands. The protoxylem lies in a broad ray which expands outwards. The metaxylem elements are very scattered and often appear isolated and at some distance from the protoxylem (fig. 6). The latter is often undifferentiated through several sections (about 30 μ), and then again appears at higher or lower levels for about 60 μ. The spiral tracheids have been stretched apart during growth. At each reappearance the protoxylem is a little nearer to the centre than below. This goes on till it is seen first to be in a line with the two metaxylem groups (fig. 6) and then slightly internal to them, forming the apex of a right angle, each of whose containing lines bisects a metaxylem group (figs. 7 & 7 *a*).

At the node the four phloem-bands break up (fig. 7); the extremities of each of them are from this point connected with the metaxylem groups, and form with them a double vascular bundle at each angle of the stele. The central portions of each band behave differently in each opposite pair. The phloem-bands perpendicular to the cotyledonary plane die out at the node in a seedling of this age (fig. 8). The phloem-bands parallel to the cotyledonary plane become here internal to the vascular bundles and form two crescents (fig. 9), which, higher, unite by their horns and, above the node, form the cylinder of the first internode. Internal to the middle of one of the lateral phloem-bands are two xylem elements. These can be traced downwards for 6·37 mm. from the node without interruption. One reappears at intervals on this side and another lower down on the opposite side; but both are lost sight of at about 32 mm. below the node, *i. e.* before root-structure appears. They are doubtless destined to supply the first internode.

The transition from stem to root characters takes place here and generally in the material examined either at the node or close below it.

Meanwhile it appears, in passing up through the node, that the protoxylem strand of each primary group forks, and each new strand takes up its position at the apex of a triangular vascular bundle (fig. 9 *a*). The two bundles are now separated by a wide ray, but before the cotyledons are completely cut off from the axis these bundles approach one another and fuse by their phloem and cambium, while their xylem consists of several

groups separated by parenchyma (Pl. 26. fig. 9). Two of these primary groups or "double bundles" pass into each cotyledon, and from the outer extremity of each group a lateral is given off (a') (fig. 10). From this branches another lateral (a''), and from a'' another (a'''). Gradually the remaining inner parts of the primary groups approach one another and fuse to form the midrib at 2·7 mm. above the node.

In *Bumelia tenax* we have a type outwardly very unlike that of *Payena Leerii*.

The *seed* is much smaller than that of any of the other species examined. It is egg-shaped; the long axis measures 8 mm., the short axis 6 mm. Inside the hard testa the cotyledons are enclosed in a thin covering layer containing little or no nutritive material; its origin has yet to be investigated. The cotyledons are very fleshy and packed with food-material. The radicle of the embryo shows no differentiation of xylem, but in the procambial strands of the cotyledons there are strands of xylem one or two cells thick.

The *seedlings* are much more slender than those of any other species examined (fig. 11). They grew very quickly and, a month after planting the seed, most of them measured 10 cm. The cotyledons are hypogeal and petiolate. The petioles are fused at their sides, forming a sheath to the base of the first internode. The shoot ruptures this sheath laterally, the cotyledons are pushed to one side, and at the stage examined the shoot often measured 4 or 5 cm. Above the rupture the petioles are seen again fused and the base of the cotyledons also forms a tube. They are only separated at a third of their length.

The anatomy of *Bumelia tenax* seedlings strikes one, at first sight, as so different from that of other types that it is difficult to believe them all to belong to the same order. On further investigation, however, it becomes evident that the essentials are similar, but that the anatomy is profoundly modified by the habit of the plant.

The *root* has, as a rule, a hexarch stele with a small pith (fig. 12). All the six protoxylems behave similarly at the root-apex, each arising as a single cell, which is gradually added to centripetally as higher levels are reached. In the upper part of the root and in the hypocotyl four of the vascular bundles are distinguished from the other two in the following ways:—

(*a*) It is from these four bundles alone that rootlets arise.

(*b*) They alone always retain their protoxylems throughout their course.

(*c*) They alone are continuous with the bundles going to the cotyledons.

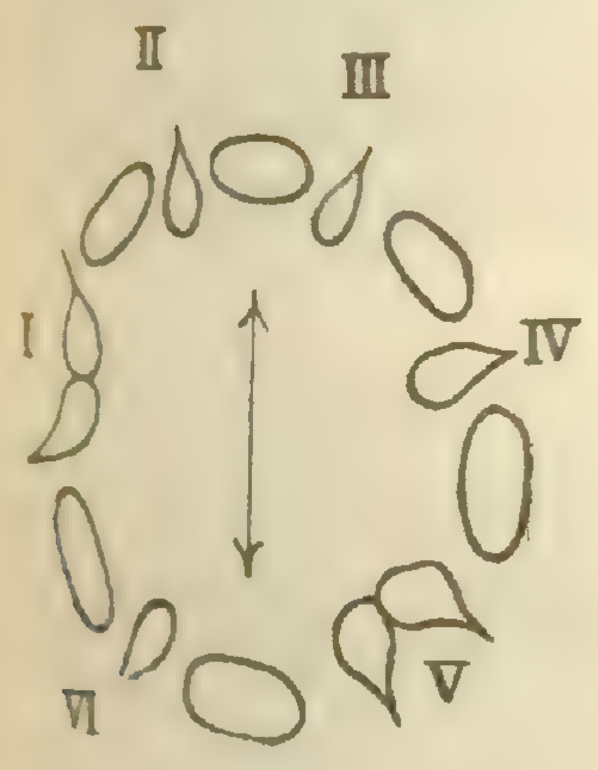
These four I regard as primary bundles and equivalent to the four vascular groups of the tetrarch *Payena* type. The two other groups lose their protoxylems while the primary bundles are still exarch and they may fork into two strands. For convenience I have called them "accessory bundles." Either they may both lie in the plane perpendicular to that of the cotyledons (Pl. 26. fig. 13), or one may be so situated and the other may be in the cotyledonary plane (text-fig. 3).

A little higher the accessory bundles are barely recognizable; but at the node several xylem groups appear on the long sides of the rectangular stele, with or without spiral elements (fig. 14). They pass into the first internode. The stem in the case in question (fig. 11 *a*) is not a vertical continuation of the hypocotyl, but is bent at an angle to it, and this fact allows one to observe the gradual break up of the hypocotyledonary

stele. The two pairs of primary bundles or vascular groups bend out in opposite directions going to the cotyledons. The accessory bundle of one side widens, forks, and then bends outwards laterally to join the spiral elements of the first internode (fig. 15). At a little higher level the lateral bundle of the other side also widens and forks and then bends laterally inwards in the same direction as those of the other side and joins the young elements of the first internode, which is here seen in longitudinal section (fig. 16). This forking of epicotyledonary traces is described by Mr. H. Wright * for *Diospyros*, also, at the node.

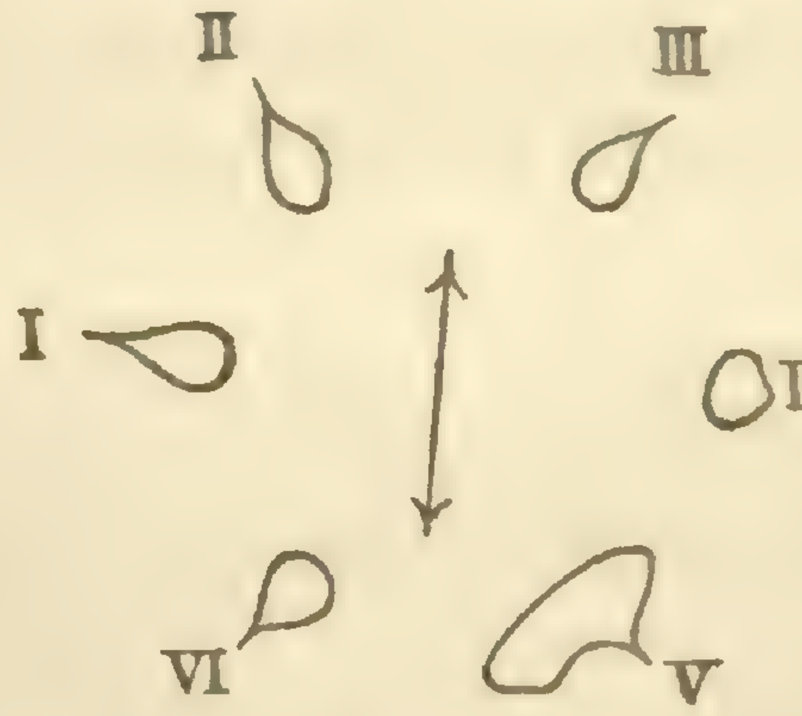
In one specimen of *Bumelia tenax* (not free from suspicion of abnormality) I have, however, counted as many as nine protoxylem points near the root-apex. Of these, one dies out about 0·8 mm. above the apex, four fuse in pairs a very little higher, leaving the usual six to continue on up the root (fig. 11 *b*). Of these six, four are primary

Fig. 1.



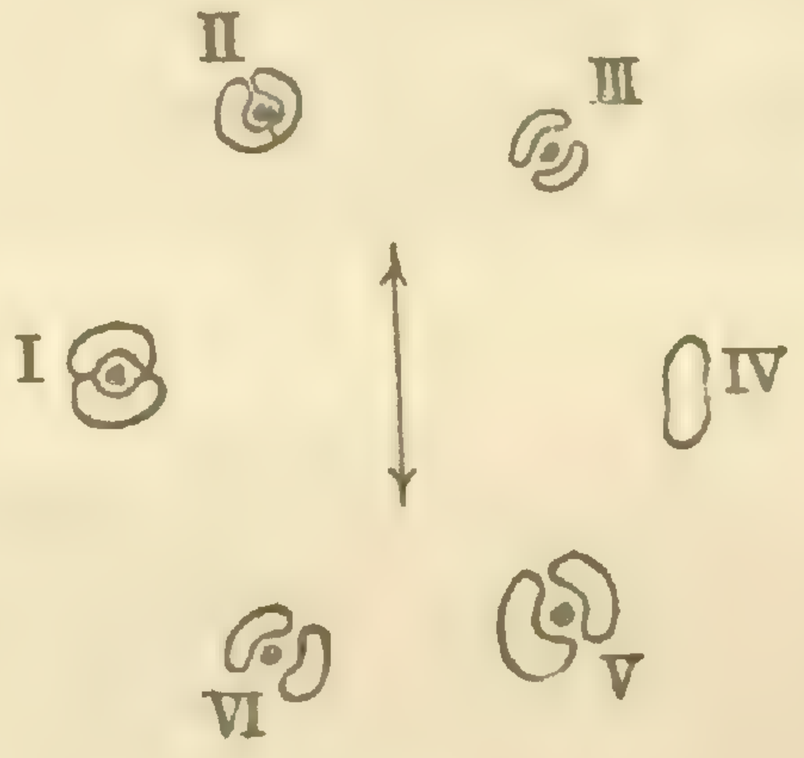
0·8 mm. above apex of root.

Fig. 2.



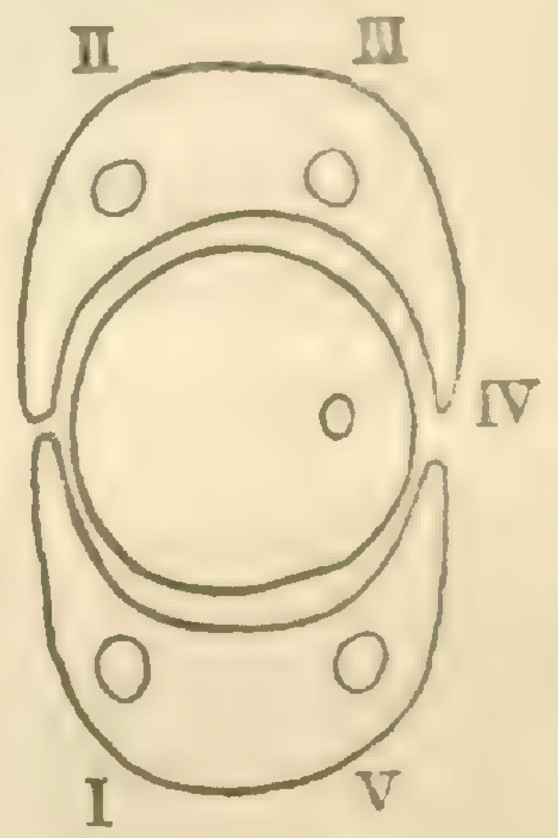
Root.

Fig. 3.



4 mm. above apex of root, and below node.

Fig. 4.



Petiole and stem.

Anomalous type of *Bumelia tenax*.

bundles, one (IV) (text-figs. 1–4) is situated in the plane perpendicular to that of the cotyledons, the other (VI) is not opposite to it but in the cotyledonary plane. The former of these two "accessory" bundles (IV) loses its protoxylem altogether a little above the plane at which the other groups cease to be root-like, *i. e.* about 4 mm. above the root-apex, where the whole axis below the node measures about 1 cm. The bundle is difficult to identify at the node, but a little higher its place becomes the region of attachment of one of the foliar traces of the stem. The other accessory bundle (VI) seemed to be destined, with the primary group on each side of it, for the cotyledon; but its protoxylem dies out at the node, part of the metaxylem enters the cotyledon and dies out there, the rest forms the point of attachment for the vascular tissue of a dormant bud, situated in the axil of the cotyledon. From the seedlings examined it appears that spiral elements arise in the bud and are connected or not with the stele according to the state of maturity reached by the bud at the time of fixing.

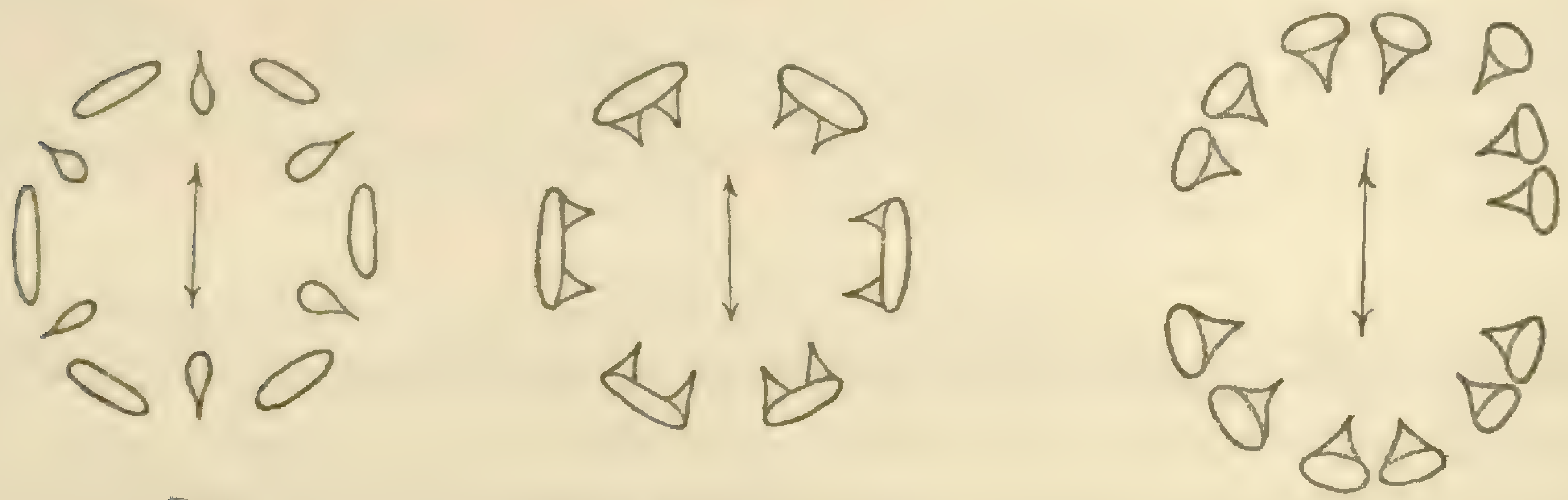
On the side of the stele where there is no root-strand, groups of xylem (not spiral) arise at the node and form a point of attachment for the young elements of the stem on that side.

* *Loc. cit.* p. 64 (*cf.* post, p. 199).

It is much more common to find the vascular groups arranged at the node as in fig. 11—*i.e.*, with no accessory bundle between the groups destined for the same cotyledons, but a lateral one on each side corresponding to the plane of separation of the cotyledons. On the whole, the changes in the relative position of the metaxylem and protoxylem of the primary bundles, which take place in the transition from root to stem, follow the same sequence as those described in *Payena Leerii.* It is noticeable here, however, that the protoxylem of the regions above the root is always isolated in a little oasis of parenchyma and separated by it from the metaxylem on each side of it, and external to it, and from the lignified parenchyma internal to it (fig. 14), almost suggesting mesarch structure.

I think that the differences between the vascular features of *Payena Leerii* and those of *Bumelia tenax* may perhaps be classed as adaptive or correlative. The smallness of the cotyledons in the latter, and the absence of reserve food-material elsewhere, throws the seedling early on its own resources; hence the rapid growth and early development of the plumular leaves, creating a demand to which the plant replies by the formation of accessory vascular strands in the root. I was unfortunately unable to compare the connection between hypocotyl and first internode in the two plants, as I had no specimen of *Payena Leerii* in which the shoot had developed.

Fig. 5. Fig. 6. Fig. 7.



Root. Node, and 2·5 cm. below. Base of cotyledon.

Palaquium petiolare.—B.

The course of the two double bundles in the cotyledons differs from that pursued in *Payena Leerii.* The double bundles diverge from one another, and the halves of the said bundles separate. A continuous branching goes on, and branches are given off not only towards the periphery but also towards the centre of the cotyledon. There is no fusion of traces and no distinct midrib, though one trace does, near the leaf-tip, occupy a nearly median position. Here fourteen veins were cut in transverse section.

In *Palaquium* (=*Dichopsis*) *petiolare* we meet with a slightly different type from those of *Payena Leerii* and *Bumelia tenax*, a type varying in anatomy even within the species. I had no seeds of this plant and only three seedlings. The cotyledons have a very short petiole and are hemispherical in shape. They are probably hypogeal, for they are very large and heavy and the shoot develops early. They show no internal

sign of a midrib, but are penetrated by one larger median vein and two smaller divergent lateral ones. On the dorsal side there is a slight keel. One type of seedling (B) was hexarch throughout, and "the vertical median plane of the cotyledons corresponded with a vascular bundle of the root." Three double bundles pass into one cotyledon and four into the other, the fourth bundle arising at the node. It is a single bundle and resembles a foliar trace (text-figs. 5–7).

In another type (A) the root was heptarch; but below the node an eighth bundle arose and four double bundles passed into each cotyledon. Here the vertical median plane of the cotyledons did not correspond with a vascular bundle of the root (text-figs. 8, 9).

Scarcity of material prevents any generalization as to which is the prevailing type in the species.

In an unnamed species of *Palaquium* from China the stele is hexarch throughout and conforms with Dangeard's axiom. Three double bundles pass to each cotyledon and fork and anastomose in it. The external features of this species are, on the whole, similar to those of *P. petiolare*, but the cotyledons are rather less thick.

Achras Sapota agrees more closely with the *Payena Leerii* type than any other species examined; but the embryo in the ripe *seed* is much less mature. No latex tissue and no lignification were apparent. A *seedling* measuring about 13 mm. from node to root-apex showed no swollen zone in the hypocotyl, no lignified parenchyma, and no secondary thickening. It was much younger than any specimen of *Payena Leerii* which I possessed. It had no foliar traces. The isolation of the protoxylem from the metaxylem groups on each side of it is very striking.

Bassia latifolia (*Illipe latifolia*) and *Bassia longifolia* (*Illipe Malabrorum*) agree in the seedling with the type on the whole, and have a zone of thickening in the hypocotyl. I had no seeds of these two species.

Mimusops Elengi agrees on the whole with *Payena Leerii*. The ripe seed contains an embryo much less advanced than that of the type—having neither latex nor vascular tissue differentiated. The procambial strands indicate a stele like that of *P. Leerii*, and this is realised in the seedling. A zone of thickening is present here in the hypocotyl at about half the length from node to root-apex (Pl. 26. fig. 18).

The behaviour of the double bundles as they pass to the cotyledons here and in *Chrysophyllum Cainito* differs slightly from the type and shows that the feature is not a constant one, and also indicates the independence of the halves of the said bundles. They do not bend out together, but whereas in *M. Elengi* the inner halves precede the outer ones, the reverse is the case with *Chrysophyllum Cainito*. Also in a specimen of *M. Elengi* showing signs of injury the two halves of a double bundle were continued into the root as separate groups, and never united at the corner of the stele.

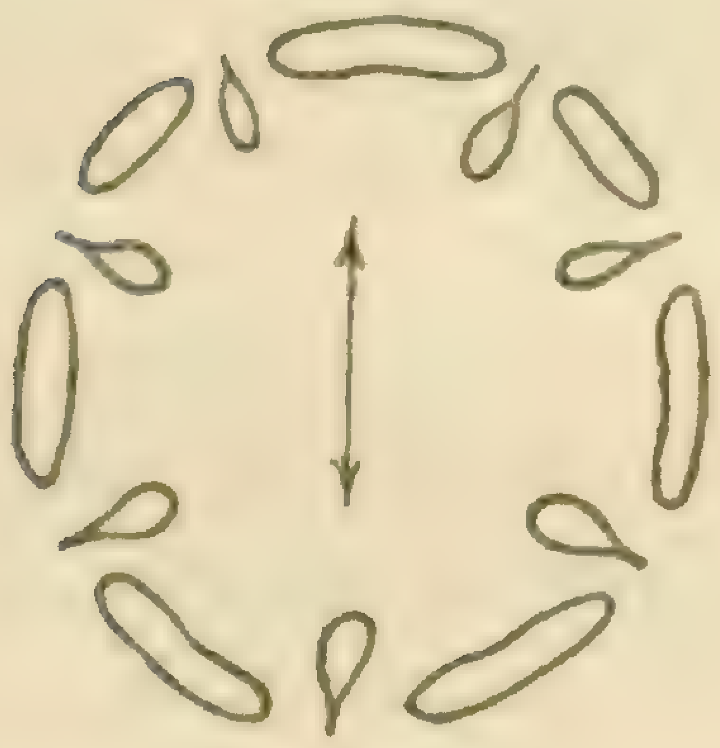
A small xylem group at the node, between the groups destined for one cotyledon, was accounted for by observing that 5 per cent. of the seedlings of this species have the first leaf vertically over a cotyledon. No other foliar traces were to be seen at this stage. About 6 per cent. of the seedlings of this species have bifid cotyledons.

Mimusops Kauki has a seed with endosperm and thin cotyledons. This species

agrees with *Payena Leerii* in the venation of the cotyledons, the transition from stem to hypocotyl, and the orientation of the vascular bundles. The tetrarch root-structure is found about 1 mm. below the node in a specimen measuring about 20 mm. from node to root-apex. I found no thickened zone and saw no foliar traces in the hypocotyl (Pl. 26. fig. 19). *Mimusops Schimperi* has the peculiarity of showing two accessory bundles near the root-apex besides the usual four. In other respects it agrees with *M. Elengi* and *M. Kauki* (text-fig. 10).

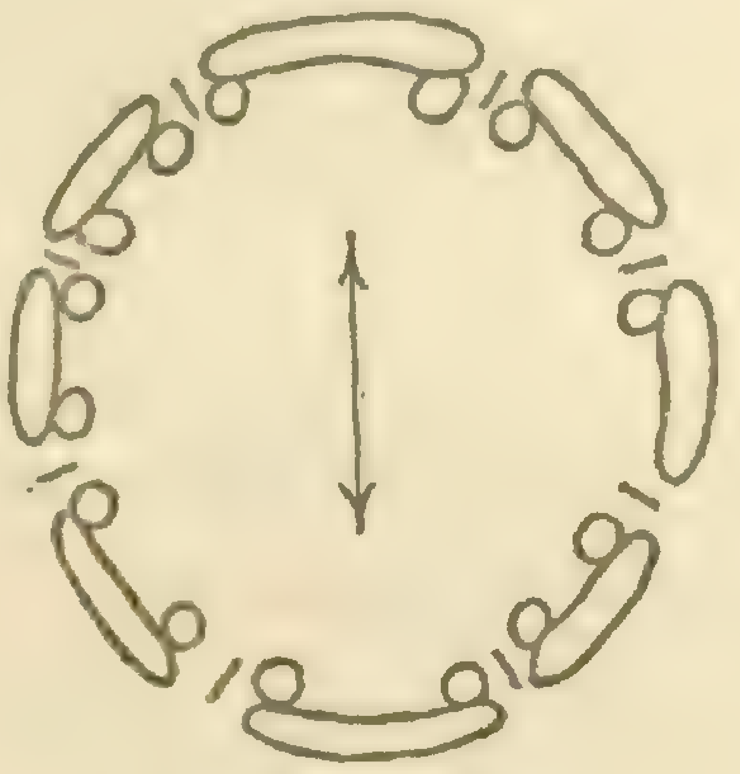
In *Chrysophyllum Cainito* also there is a general agreement with the type. The cotyledons are more bulky and the endosperm thinner. The embryo is less mature in the ripe seed. In the six seedlings examined no zone of thickening like that in the hypocotyl of *P. Leerii* was seen. The smallest of these measured 6·5 mm. from node to root-apex, the largest 145 mm. The latter was thickened throughout. Root-characters were observed in the primary groups up to the node, so that the transition

Fig. 8.



8 mm. above apex of root.

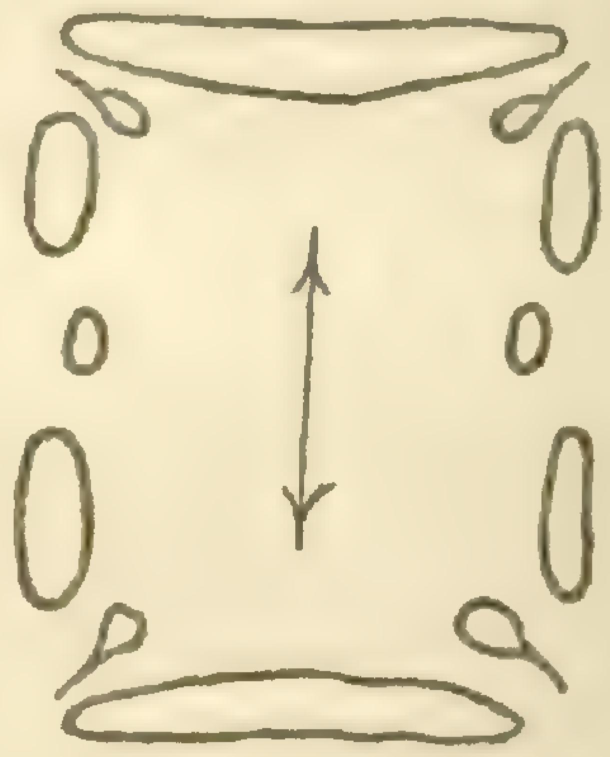
Fig. 9.



3 mm. below node.

Palaquium petiolare.—A.

Fig. 10.



6 cm. below node, near apex of root.

Mimusops Schimperi.

takes place in and above the node. The protoxylem only becomes internal at the base of the cotyledons. The whole of the outer halves of the double bundles go off in the cotyledons as lateral veins, and the midrib is thus formed by a fusion of the two inner halves; not, as in *Payena Leerii*, of these and of parts of the outer halves also.

Chrysophyllum Roxburghii is also in general agreement. The embryo shows no xylem except at the distal end of the cotyledons. These are thinner than those of *C. Cainito* and the endosperm is bulkier. In the *seedling* root-structure is found close up to the node as in *C. Cainito*. A zone of the axis about 1 cm. deep and about halfway between the node and the root-apex was considerably enlarged, but the internal structure included no secondary thickening, only lignified parenchyma which reduced the pith to half its diameter (Pl. 26. fig. 17).

Chrysophyllum olivæforme has a smaller seed than the other species I have examined of the genus. Tracheids only appear in the upper half of the cotyledons, in the embryo of the ripe seed. Latex is first seen near the surface of the cotyledons which abuts on the endosperm. The anatomy of the seedling agrees with that of *P. Leerii*, but, in a specimen measuring 8 cm. from node to root-apex and with a shoot 1 cm. above the

node, foliar traces were seen at the node on all four sides of the stele. These died out above the appearance of root-structure in the primary groups. A swollen zone occurs about halfway between node and root-apex, but only extends for about 5 mm., and tapers gradually above. Both lignified parenchyma and secondary xylem are present in this region.

I had no seeds of *Imbricaria coriacea*. The seedlings had thin cotyledons and a bulky endosperm, and their radicles were, in three cases out of four, coiled in a spiral. They were in general agreement with the *Payena Leerii* type and had a well-marked zone of thickening. The flat cotyledons showed in transverse section a central vein larger than the others (which were numerous) and corresponding with external grooves on both sides.

Table to show the main Features of the Species examined.

	Lower Root-stele	Upper Root-stele	Hypocotyl	Swollen Zone	Cotyledons	Endosperm	Veins of Cotyledons
Payena Leerii	tetrarch.	tetrarch.	tetrarch.	present.	flat, sessile, epigeal.	bulky.	midrib and laterals.
Achras Sapota	do.	do.	do.	absent.	do. do. do.	do.	do.
Bassia longifolia	do.	do.	do.	present.	fleshy, petiolate.	?	small and scattered.
B. latifolia	do.	do.	do.	do.	do. do.	?	
Mimusops Elengi	do.	do.	do.	do.	thin, sessile, epigeal.	bulky.	midrib.
M. Schimperi	hexarch.	do.	do.	do.	do. do. ?	do.	do.
M. Kauki	tetrarch.	do.	do.	do. slight.	do. do. ?	present.	do.
Chrysophyllum Cainito ..	do.	do.	do.	absent.	thick, sessile, epigeal.	do.	do.
C. Roxburghii	do.	do.	do.	present.	flat, sessile, epigeal?	bulky.	do.
C. olivæforme	do.	do.	do.	do.	do. do. ?	do.	do.
Imbricaria coriacea	do.	do.	do.	do.	thin, sessile, ?	do.	do.
Bumelia tenax	hexarch, polyarch.	do.	do.	absent.	fleshy, petiolate, hypogeal.	very slight.	small and scattered.
Palaquium petiolare	hexarch, heptarch.	hexarch, heptarch.	hexarch, heptarch, octarch.	present.	hemispherical, petiolate.	?	do.
Palaquium sp.	hexarch.	hexarch.	hexarch.	do.	do. do.	?	do.

Summary.

1. A swollen zone in the hypocotyl, corresponding with a band of secondary thickening, or with lignification of the pith, or with both, is seen in ten out of the fourteen species examined. Phloem is well developed. Other geophilous features are prominent in *Bumelia tenax*.

2. The vascular system of primary root and hypocotyl is typically tetrarch and corresponds with two bundles from each cotyledon without change of position. In *Mimusops Schimperi*, however, there is a hexarch root, and *Bumelia tenax* and two species of *Palaquium* are variable and anomalous, tending to be hexarch. The occurrence of the hexarch type might lead one to suspect that a central cotyledonary trace had aborted in the tetrarch type, as described in some species of *Diospyros* by Mr. Herbert Wright *. But in the tetrarch types of which I had seeds I could not discover, even in the embryo,

* *Loc. cit.* (*cf.* post, p. 199).

any sign of lignification in the position of a central trace. The midrib of the cotyledon was formed as indicated in Pl. 26. fig. 10. The primary vascular bundles lie typically parallel to the cotyledonary plane, but are not intersected by it.

3. Vascular system of the cotyledons:—The first differentiation of xylem is seen at the tip of the cotyledon and progresses downwards through the node. The two strands of metaxylem belonging to each double vascular bundle remain separate and are seen halfway between the cotyledonary node and the root-apex to be placed each side of the xylem of the primary root-strand. Protoxylem-strands of the cotyledon, if double above, fuse at the node and occupy a median position. In *Bumelia tenax* the protoxylem strands of the cotyledon are single and occupy a median position between the members of a double group of metaxylem. They are completely isolated by parenchyma in *Payena Leerii*, *Bumelia tenax*, and *Chrysophyllum Cainito*.

4. Root system:—Lignification progresses from the node downwards, dying out gradually near the root-apex. The continuity of the protoxylem is sometimes interrupted for short distances, probably owing to stretching during growth.

5. Stem system:—Differentiation of xylem begins at the node and progresses downwards. In *Bumelia tenax* there is marked lack of continuity. The small spiral and annular tracheids belonging to the traces of the first internode do not reach to the node. This break is perhaps only an exaggeration of what is seen in the protoxylems of the root and to be accounted for by the rapid elongation of the shoot (see *Bumelia tenax*, fig. 11 *b*,). As in *Diospyros* the foliar traces fork and spread out at the node in this species, and are represented by a reduced number of bundles above and below the node.

6. Accessory system of the root:—In *Bumelia tenax* we meet with a number of strands not primary, which I have called the accessory system of the root. The strands which constitute this system do not correspond in number and position with the foliar traces which appear at the node.

At the stages of development observed in the seedlings and seeds described the separateness of differentiation obtaining in these different vascular systems is very marked and clear.

The impression derived from a study of these Sapotaceous seedlings is that, while there is a characteristic type of anatomy for the order, it is subject to adaptive variations as to number of strands primary and otherwise; but is constant as regards their structure, which in the primary strands is always dual.

This work was done at the Royal College of Science and the germination of seeds and raising of seedlings was arranged for in the Chelsea Physic Garden. I need hardly say how invaluable it has been to me to work under the counsel and criticism of Professor Farmer.

[NOTE.—Since the above went to press, my attention has been drawn to M. Matte's paper * on the seedling anatomy of *Ceratozamia* and *Stangeria*. He finds lack of continuity at the node and accessory root-strands, as I do in *Bumelia*; but he puts a different interpretation on the facts.—W. S.]

[2 *Feb.*, 1909.]

* *Loc. cit.* (*cf.* post, p. 199).

Bibliography.

R. Gérard.—"Recherches sur le passage de la racine à la tige." Ann. des Sci. Nat. Bot. 6ième série, tom. xi. 1881, p. 279.

P. Dangeard.—"Recherches sur le mode d'union de la tige et de la racine." Le Botaniste, 1ère série, 1889, p. 75.

E. Sargant.—"A new Type of Transition from Stem to Root in the Vascular System of Seedlings." Ann. Bot. vol. xiv. no. lvi. (Dec. 1900).

E. Sargant.—"Origin of the Seed Leaf in Monocotyledons." New Phytologist, vol. i. no. 5 (1902).

E. N. Thomas.—"A Theory of the Double Leaf-trace founded on Seedling Structure." New Phytologist, vol. vi. p. 77 (1907).

H. Wright.—"The Genus *Diospyros* in Ceylon." Ann. R. Bot. Gar. Peradeniya, vol. ii. pt. 1 (1904).

H. Matte.—'Sur la développement morphologique et anatomique de germinations des Cycadées.' Caen, 1908.

EXPLANATION OF PLATES 25 & 26.

Abbreviations and symbols:—

Black or *px.*	indicates protoxylem.
Circles or *mx.*	„ metaxylem.
Hatching or *lig.par.*	„ lignified parenchyma.
cbm.	„ cambium.
t.	„ testa.
cot.	„ cotyledon.
pet.	„ petiole.
Dots or *ph.*	„ phloem with latex, &c.
Radial lines or $x.^2$	„ secondary xylem.
White or *par.*	„ ground-tissue.
end.	„ endodermis.
al.	„ endosperm.
l.	„ latex-cell.

Payena Leerii. Figs. 1–10.

Fig. 1. Seedling of *Payena Leerii* with thickened zone shaded. Horizontal lines mark the position of sections illustrated. ×1.

Figs. 2–8. Diagrams of a series of transverse sections of the stele of fig. 1, to show transition from root to stem. All are on the same scale. The vertical line indicates the cotyledonary plane.

Fig. 2. Transverse section of the root-stele 82·1 mm. below the node.

3. Transverse section of the root-stele 81·4 mm. below the node, to show the increase in number of metaxylem elements.

Fig. 4. Transverse section of the root-stele 48·2 mm. below the node and about the middle of the swollen zone, to show further increase in number of metaxylem elements, formation of secondary xylem, and lignification of pith.

4 *a*. Transverse section of one of the vascular groups in fig. 4.

5. Transverse section of the root-stele 36 mm. below the node and at the upper end of the swollen zone, to show the forking of the metaxylem and the dying out of the secondary xylem and of the lignification of the pith.

6. Transverse section of the hypocotyledonary stele 12·5 mm. below the node, to show the formation of two collateral vascular bundles from one root-bundle, with protoxylem between them.

7. Transverse section at the node, to show the break up of the phloem-bands.

7 *a*. Transverse section of one of the double bundles in fig. 7. Protoxylem is now internal.

8. Transverse section a little higher in the node than fig. 7, to show the disappearance of the phloem from the cotyledonary plane.

9. Transverse section of the node, to show the passing out of the two double bundles of the axis to the cotyledons, and the beginning of the formation of the axis of the stem from the remains of the phloem of the hypocotyl. On a smaller scale than figs. 2–8.

9 *a*. Transverse section of one of the vascular groups of fig. 9, to show the forking of the protoxylem.

10. Venation of one of the cotyledons and half of the axis.

Bumelia tenax. Figs. 11–16.

Fig. 11. Two seedlings of *Bumelia tenax* (11 *a* & 11 *b*), life-size, and the nodal region of another (11 *f*). × 2.

Figs. 12–16. Diagrams of steles, to show the transition of seedling 11 *a* on approximately the same scale as figs. 2–8.

Fig. 12. Transverse section of hexarch root-stele.

12 *a*. Transverse section, about 2 mm. below node, of a primary and an accessory vascular strand from fig. 12. Both have exarch protoxylem.

13. Transverse section of the tetrarch root-stele with two accessory vascular strands. A little higher than fig. 12.

13 *a*. Transverse section of the same two strands as those drawn in fig. 12 *a*, showing that the primary strand alone has exarch protoxylem. These are taken from fig. 13.

14. Transverse section of the stele at the node with protoxylem no longer exarch, to show the forking of the accessory strands.

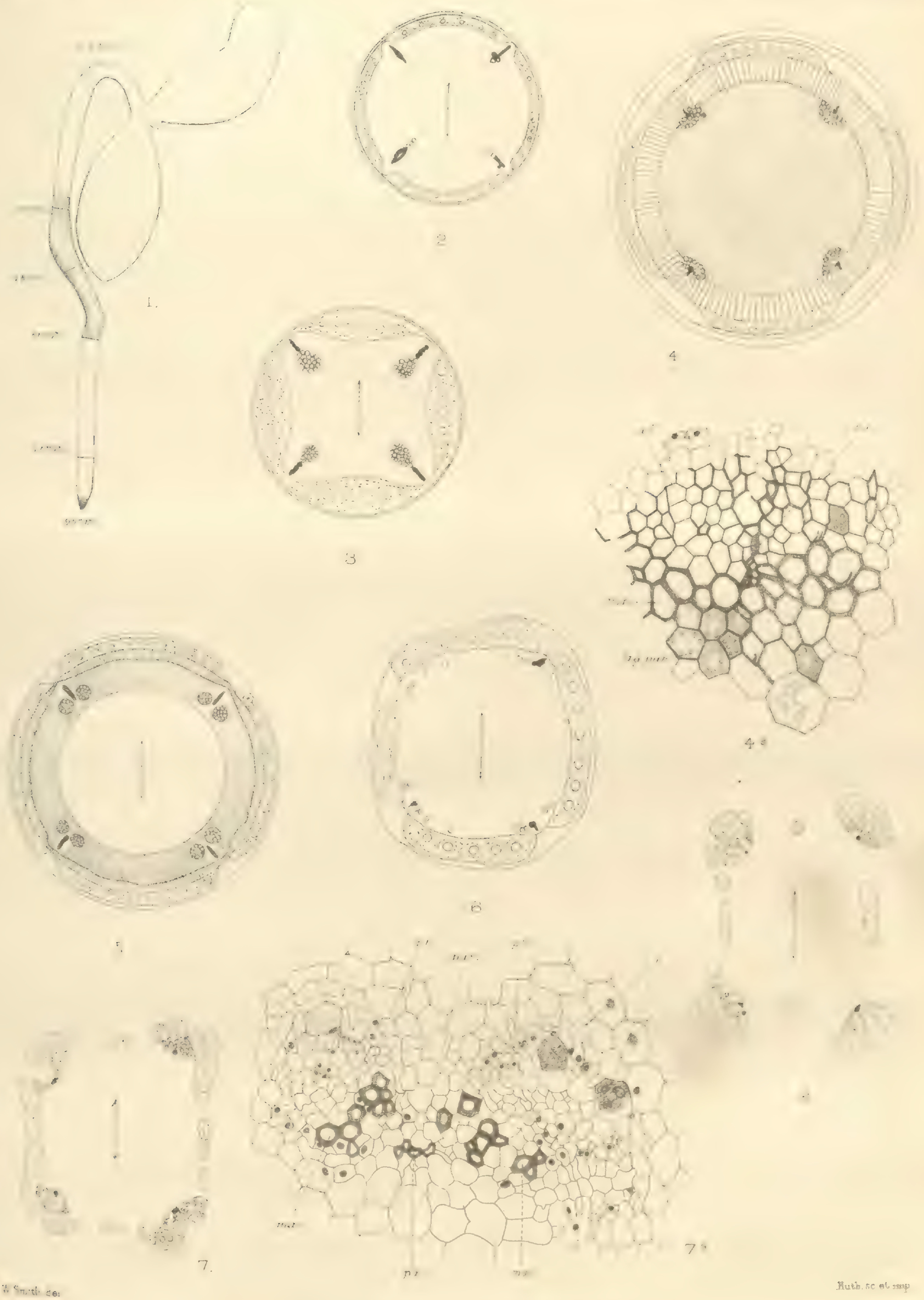
15. Transverse section of the axis of the hypocotyl and longitudinal section of the axis of the plumular bud, showing the accessory strands of one side of the stele bending laterally to the bud.

16. The same at a slightly higher level, showing the accessory strands of the opposite side of the stele also bending laterally to the bud.

17. Seedling of *Chrysophyllum Roxburghii* with swollen zone. × 1.

18. Seedling of *Mimusops Elengi* with swollen zone. × 1.

19. Seedling of *Mimusops Kauki*. × 1.



W. Smith del.

Ruth sc et imp

SEEDLINGS OF SAPOTACEAE.

W. Smith del.

Huth sc et imp.

SEEDLINGS OF SAPOTACEAE.

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s.* to the public, and 6*s.* to Fellows; to Vols. 26–30, 4*s.* to the public, and 3*s.* to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

Second Series.—Botany.

Volume.	Part	When Published.	Price to the Public. £	*s.*	*d.*	Price to Fellows. £	*s.*	*d.*
I.	Part I.	1875.	0	8	0	0	6	0
	Part II.	1875.	0	16	0	0	12	0
	Part III.	1876.	0	12	0	0	9	0
	Part IV.	1876.	0	10	0	0	7	6
	Part V.	1878.	1	4	0	0	18	0
	Part VI.	1879.	1	6	0	0	19	6
	Part VII.	1880.	1	4	0	0	18	0
	Part VIII.	1880.	1	1	0	0	16	0
	Part IX.	1880.	1	0	0	0	15	0
II.	Part I.	1881.	0	12	0	0	9	0
	Part II.	1882.	0	5	0	0	3	9
	Part III.	1883.	0	10	0	0	7	6
	Part IV.	1883.	0	3	0	0	2	3
	Part V.	1883.	0	3	0	0	2	3
	Part VI.	1884.	0	13	6	0	10	0
	Part VII.	1884.	0	9	6	0	7	0
	Part VIII.	1884.	0	10	0	0	7	6
	Part IX.	1886.	0	7	0	0	5	0
	Part X.	1887.	0	3	4	0	2	6
	Part XI.	1886.	0	6	0	0	4	6
	Part XII.	1886.	0	8	0	0	6	0
	Part XIII.	1887.	1	7	0	1	0	0
	Part XIV.	1887.	0	7	0	0	5	0
	Part XV.	1887.	0	10	0	0	7	6
	Part XVI.	1888.	0	2	6	0	2	0
III.	Part I.	1888.	3	12	0	2	14	0
	Part II.	1891.	0	5	0	0	3	9
	Part III.	1891.	0	7	0	0	5	0
	Part IV.	1891.	0	6	0	0	4	6
	Part V.	1891.	0	6	0	0	4	6
	Part VI.	1891.	0	3	6	0	2	8
	Part VII.	1892.	0	6	0	0	4	6
	Part VIII.	1893.	0	6	0	0	4	6
	Part IX.	1893.	1	8	0	1	1	0
	Part X.	1894.	0	10	0	0	7	6
	Part XI.	1894.	0	3	4	0	2	6
IV.	Part I.	1894.	1	0	0	0	15	0
	Part II.	1894.	2	0	0	1	10	0
	Part III.	1895.	2	10	0	1	17	0

Second Series.—Botany (*continued*).

Volume.	Part	When Published.	Price to the Public. £	*s.*	*d.*	Price to Fellows. £	*s.*	*d.*
IV.	Part IV.	1895.	0	3	4	0	2	6
V.	Part I.	1895.	0	9	0	0	6	9
	Part II.	1895.	0	12	0	0	9	0
	Part III.	1896.	0	6	0	0	4	6
	Part IV.	1896.	1	0	0	0	15	0
	Part V.	1896.	0	14	0	0	10	6
	Part VI.	1896.	0	4	0	0	3	0
	Part VII.	1897.	0	4	0	0	3	0
	Part VIII.	1897.	0	6	0	0	4	6
	Part IX.	1899.	0	12	0	0	9	0
	Part X.	1899.	0	6	0	0	4	6
	Part XI.	1899.	0	7	0	0	5	0
	Part XII.	1899.	0	12	0	0	9	0
	Part XIII.	1900.	0	1	6	0	1	2
	Part XIV.	1900.	0	3	0	0	2	3
	Part XV.	1901.	0	6	0	0	4	6
VI.	Part I.	1901.	1	10	0	1	2	6
	Part II.	1901.	0	6	0	0	4	6
	Part III.	1902.	0	18	0	0	13	6
	Part IV.	1903.	0	8	0	0	6	0
	Part V.	1903.	0	8	0	0	6	0
	Part VI.	1903.	0	12	0	0	9	0
	Part VII.	1904.	0	12	0	0	9	0
	Part VIII.	1904.	0	12	0	0	9	0
	Part IX.	1904.	0	7	0	0	5	3
	Part X.	1904.	0	14	0	0	10	6
	Part XI.	1905.	0	4	0	0	3	0
VII.	Part I.	1904.	0	5	0	0	3	9
	Part II.	1905.	0	6	0	0	4	6
	Part III.	1906.	0	3	0	0	2	3
	Part IV.	1906.	0	7	0	0	5	3
	Part V.	1907.	0	10	0	0	7	6
	Part VI.	1907.	0	4	0	0	3	0
	Part VII.	1907.	0	6	0	0	4	6
	Part VIII.	1908.	0	5	0	0	3	9
	Part IX.	1908.	0	2	6	0	2	0
	Part X.	1908.	0	7	0	0	5	3
	Part XI.	1909.	0	4	0	0	3	0

2nd Ser. BOTANY.] [VOL. VII. PART 12.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

A REVISION OF THE GENUS NOTOTRICHE, TURCZ.

BY

ARTHUR W. HILL, M.A., F.L.S.

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

July 1909.

XII. *A Revision of the Genus* Nototriche, *Turcz.*

By Arthur W. Hill, *M.A.*, *F.L.S.*

(Plates 27–30.)

Read 21st January, 1909.

Introduction.

Among the rosette and cushion forming plants of the high Andes there are two well-defined groups of Malvaceæ which are distinguished from other members of this order by their apparently acaulescent habit and thick, woody, underground caudex. In the one case the flowers are provided with involucres and are borne in the axils of the basal leaves; such plants are typical members of the genus *Malvastrum* of Asa Gray. The other group, which is also the larger, is distinguished especially by the adnation of the peduncles and stipules to the petioles and by the absence of the involucral bracts or epicalyx (*Malvastra Phyllanthophora*, A. Gray).

For this latter group the name *Nototriche* of Turczaninow has been revived *.

In a recent paper † Count Solms-Laubach considers the revival of this name to be "gänzlich unnöthig und müssig," but the characters which serve to differentiate the genus *Nototriche*, as here understood, from *Malvastrum* appear amply to warrant the separation. In *Nototriche* there is no epicalyx, which is almost always found in *Malvastrum* ‡, the peduncles are adnate to the petioles, and the stipules are always united with the petioles to form a kind of protective vagina, and these features are peculiar to the genus *Nototriche*. The carpels are also beaked to a greater or less extent in practically all the known cases and are more or less dehiscent.

The name *Malveopsis*, Presl, has also been revived by O. Kuntze § to supplant the names *Malvastrum* and *Malva*: as this has not been followed by other writers, it is not necessary to enter further into the question in this paper.

Before proceeding to the diagnoses of the numerous species, a short general account of the genus is given; this is followed by remarks on some points of interest in the biology and geographical distribution of the various species. A few notes are added on the collectors to whose industry we are indebted for our knowledge of the Andean flora.

The numerous forms collected together under the genus *Nototriche* constitute a very natural group. Out of some sixty-seven species already known, only two are annuals, though doubtless many more exist.

The Root and Stem.—Among the perennial species the habit of growth is essentially the same in all cases; there is a firm woody underground stem passing imperceptibly into the tap-root and in some few cases there appears to be a more or less definite aerial stem.

* Hill, A. W., in Engl. Bot. Jahrb. xxxvii. (1906) p. 577.

† Solms-Laubach in Bot. Zeit. 1907, p. 123.

‡ In *M. nubigena* the epicalyx is sometimes aborted, and in the specimens of *M. oriastrum* collected by Weddell it is undeveloped.

§ O. Kuntze, Rev. Gen. Plant. iii. 2, p. 20.

In nearly every specimen the underground stem is branched and each branch is surmounted by a rosette of leaves, which may be closely aggregated to form dense compact masses or loosely arranged in lax and spreading rosettes. Owing to the close packing of the branches the separate plants often form little hard cushions of several centimetres in diameter.

A well-marked branched aerial stem occurs in *N. Lobbii*, while both *N. compacta* and *N. clandestina* appear to have their caudices branched above ground.

In some cases (e. g. *N. Azorella*, &c.) the branches may be arranged more or less vertically (Pl. 27. fig. 3), giving rise to a firm, hard, hemispherical cushion, while in others, e. g. *N. pichinchensis*, the branches may take the form of horizontal stolons and the plants then tend to form an even carpet over the ground; branching of this character is

Nototriche turritella on the side of El Misti, Arequipa.

shown also by the annual species *N. pusilla* (Pl. 29. fig. 20). In certain species the stem apparently does not branch; this is more particularly the case in the forms with bipinnatifid leaves, where the plants usually form small isolated somewhat lax and spreading rosettes.

The underground stem often attains to a considerable length and thickness, being as much as 2·5 cm. in diameter in one of Weberbauer's specimens of *N. sulphurea*, whilst in my own specimens of *N. turritella* it measured 1–1·5 cm. in diameter and, including the root, over 60 cm. in length (Pl. 27. fig. 2).

Of this length it seems that nearly 40 cm. belong to the stem proper, judging from what appear to be the remains of the leaf-scars between the ring-like markings due to the contraction of the stem. If a perfect specimen had been obtained it is probable that the

extremities of the root would have been found to extend to a depth of nearly a metre below the surface of the soil.

The leaf-rosette in this species, on the other hand, only protrudes from 1–2 cm. above the surface of the ground, so that the contrast between the underground and the aerial portions of the plant is very marked. A similar state of affairs is seen in all the other species of this genus and is of course characteristic of nearly all the high Andean plants. It is, however, unfortunate that, except in the case of *N. turritella*, there is scarcely a perfect specimen of *Nototriche* to be found in our herbaria *.

Each leaf-rosette in *N. turritella* is like a little cylinder of some 2–2·5 cm. in diameter and from 3–12 cm. in length, but owing to the pronounced root-shortening and stem-contraction, the stem apex never rises more than a centimetre or two above the surface of the soil. This continual burying of the stem is no doubt assisted by the loose volcanic ash in which these plants grow, and which accumulates in and about the cushions. The upper parts of the underground stem or its branches are thus clothed with leaves or leaf-bases for some distance below the surface of the soil, and there can be no doubt that the petioles with their adnate stipules—the vaginæ—afford a very efficient protective covering, especially as they are so often covered by a dense felt of stellate hairs.

In *N. aretioides* the petiole-bases are further provided with sharp spines on their dorsal surfaces (Pl. 29. fig. 16), and in many cases—especially in the forms with bipinnatifid leaves (e. g. *N. anthemidifolia*, &c.)—the vaginæ are clothed on their inner surface with a felt of long soft hairs.

The Stipules.—The fusion of the stipules to the petiole to form a kind of vagina is one of the chief characteristics of the genus, and this fusion, which is usually continued as far as the middle of the petiole, may extend in some cases almost to the lamina. The free portions of the stipules may be long and filiform (*cf.* Pl. 29. figs. 1, 2, 6, &c.) or short and broad (*cf.* Pl. 28. figs. 9–12, &c.); in some species they are quite similar in character to the leaflets, whilst in others they retain the more or less membranous appearance of the "vagina."

The primary and principal function of the stipules is no doubt bud-protection, but they continue to protect the stems long after the leaf-lamina has broken off, for the petioles are not easily detached and may be found covering the stem some distance below the surface of the soil.

The Leaves.—It is in the leaf-lamina, however, that some of the most interesting peculiarities of the genus are to be found. The original type may be assumed to be a 5-lobed, palmate lamina, and such a simple form is retained in many species. From this condition a complicated series of forms, characteristic for definite species, appears to have been developed by secondary and tertiary lobing or subdivision of some or all of the original five lobes. To such an extent has this process been carried that in some species (e. g. in *N. sajamensis*, &c.) the palmate character of the leaf is almost lost sight

* A small species of *Astragalus* which I found growing with *N. turritella* on the slopes of El Misti in Peru affords an even more striking case: an old plant which formed a small carpet on the surface of the soil about 15 cm. in diameter and not more than 4 mm. in height had an underground stem and tap-root extending vertically downwards about a metre.

of, and the lamina is seen to consist of a great number of tiny lobulæ. An opposite tendency in the direction of reduction must, however, also be noted, for in one species, *N. clandestina* (a native of the Atacama desert), a simple leaf-lamina appears to have been derived from the palmate type owing to the suppression of the lateral lobes *.

The ternate type of leaf found in a few species (e. g. in *N. aretioides*, *N. artemisioides*, &c.) may also be considered as reduced from the 5-lobed leaf by the suppression of the external pair of lobes, since in rare cases traces of the lost pair of lobes may be found.

It has been found possible to separate the various species into groups mainly on the type of the leaf-lamina and in this direction several tendencies in the mode of lobation of the lamina have been noted. In some species the lobing is only carried to the middle of the lamina, whilst in others the lamina is cut almost to the base, and this latter tendency culminates in those forms in which the leaf-lamina is dissected into a large number of linear segments, e. g. *N. pedatiloba*, *N. sajamensis* (Pl. 28. fig. 12).

The various species falling into these groups can be further differentiated owing to the fact that the middle lobe of the leaf may remain comparatively simple or else may be lobed or subdivided in the same manner as the lateral lobes.

The question of the behaviour of the median lobe introduces the consideration of the bipinnatifid group, in which a large number of species, and more particularly those which occur in the southern part of the range of the genus, are included.

Owing to the strong development of the median lobe of a 5-lobed leaf accompanied by deep cutting and lobation of the segments, it appears that a palmatilobed type of leaf with more or less pinnatifid segments like that of *N. argyllioides* may have arisen (*cf.* Pl. 27. figs. 6, 7). A deeply palmatifid type of leaf with similar and equal segments may have developed in the first place, and then, owing to the gradual increase in size of the median lobe, all stages in the evolution of a well-marked bipinnatifid leaf may have taken place. With the further development of the median lobe and its lateral segments or pinnæ, the most advanced type of bipinnatifid leaf is reached. In such cases, which are well illustrated by *N. anthemidifolia* and allied species, the original lateral lobes appear to be but little more developed than the segments of the highly developed median lobe (*cf.* Pl. 27. fig. 8). It is worth while in passing to call attention to a possible analogy, in the relation of the palmate to the pinnate types of leaf, between the species of this genus and of the fan and fern-leaved varieties of the Chinese Primula, *P. sinensis*, since the fern-leaved type appears to be a definite sport from the fan-leaved type, due, as it seems, to the vigorous development of the median lobe. It may be, then, that the palmate and pinnate forms of *Nototriche* owe their origin to an original tendency in an ancestral type to produce offspring with either a palmate or pinnate form of leaf, and from this tendency has resulted the extraordinary diversity of leaf-form to be found in this genus.

Since two or three species of very different leaf-type may be found growing close to one another under exactly similar conditions, it does not appear that one particular form of leaf is better adapted than another to any definite and given set of conditions.

Tomentum.—The distribution and character of the hairs on the lamina and petiole are

* *Cf.* the apparently simple leaves of *Berberis vulgaris*, *Robinia monophylla*, &c.

often of considerable systematic value. Humboldt noticed the peculiarity of these plants, that if the lamina is hairy on one side only, the hairs are always on the upper surface (*cf.* Pl. 29. fig. 12). As a general rule it is found that when hairs occur all over the leaf, the tomentum on the upper surface is more dense than, and is somewhat different in character from, that on the lower surface *.

The tomentum is composed of stellate hairs which vary much in character throughout the genus, but a definite form of hair is perfectly constant for each particular species. In some cases the leaves are velvety owing to the close felting together of very small stellate hairs; in others the tomentum is loose and shaggy, owing to the fact that the stellate hairs are large and borne on long stalks. Then, again, the stellate hairs may be sessile, but the rays of the star may be so long that the leaf appears to be covered by long silky hairs (e. g. *N. sericea*, &c.).

In some species an almost peltate hair occurs, somewhat resembling that of *Elæagnus*, owing to the great number of the radiating arms or branches of the "star." Then, again, the arms of the hairs may be short or long, and this gives rise to different types of hairiness. Another group of species can be recognised where the stellate hairs have relatively few radiating arms, and yet a third group in which the radiating arms though very few (3–6), are long and silky. As these differing types of stellate hair may be combined with either the stalked or sessile condition it will be realised that a considerable amount of variation in the type of tomentum exists in the genus.

In the case of *N. aretioides* (Pl. 29. figs. 15, 16) the stellate hairs on the "vagina" have become modified into definite spines with four to six arms and as the "vaginæ" are persistent on the stem long after the laminæ have fallen, it seems likely that these spines are of some definite protective value to the plant.

The Calyx.—The calyx may be hairy like the leaves, but as a rule, and especially in the species with densely aggregated leaves, only the protruding tips of the calyx-segments are felted with hairs, the rest of the calyx being glabrous since it is embedded among and protected by the leaf-bases.

Within the calyx and situated at the base of each segment are five glandular patches, the nectaries, composed of a large number of short, erect, multicellular hairs (Pl. 30. figs. 2, 3). The glandular hairs are very closely packed together, and consist usually of several tiers of four cells passing into a double row of cells and capped by a single dome-shaped cell (Pl. 30. fig. 4). As these nectaries are arranged alternately with the petals, they can be readily reached by an insect pushing its proboscis through the cleft between two adjacent petals just before their point of fusion with the staminal tube (Pl. 30. fig. 2). Similar glandular nectaries have been found in the acaulescent species of the genus *Malvastrum*, A. Gray.

The Corolla.—The corolla conforms to the common Malvaceous type, but two distinct forms are found in this genus. In some species there may be a fairly long corolla-tube fused with the staminal tube (from 2–6 mm. in length) and often covered with stellate hairs (Pl. 30. fig. 4); while in others the corolla-tube may be practically

* In the acaulescent *Malvastra* the leaves are, as a rule, glabrous on the upper and hairy on the lower surface: when hairs are present on the upper surface the lower is also hairy.

absent, the petals being united to the staminal column only at the base (Pl. 30. figs. 8, 9); this latter type occurs in only a few species and is usually found to be correlated with a definite arrangement of the stamens in an elongated cylindrical head. In the following species the corolla-tube is practically absent, *N. pichinchensis*, *N. phyllanthos*, *N. Hartwegii*, *N. Macleanii*, *N. condensata*, *N. flabellata*, *N. pediculari-folia*, *N. Lorentzii*, *N. Matthewsii*, *N. stenopetala*, *N. epileuca*. Both in *N. condensata* and *N. flabellata*, the stamens are arranged in a globose head, and the free portions of the filaments are of some length. In *N. Lobbii*, *N. Jamesonii*, and *N. sulphurea*, the stamens are arranged in a cylindrical head, but in each case there is a short corolla-tube present, 2 mm. long in *N. Lobbii*, 2–2·5 mm. in *N. sulphurea*, and 3–4 mm. in length *N. Jamesonii*. The colour of the corolla is usually violet or pinkish lilac, sometimes becoming pale blue or white; occasionally it is a deep crimson as in *N. flabellata*, *N. epileuca* or *N. stenopetala*, or a deep blue as in *N. condensata*. *N. coccinea* appears to be unique in having a scarlet corolla, whilst in *N. Lobbii* it is orange in the dry state. The corolla may be large and conspicuous in comparison with the size of the plant, especially in *N. pichinchensis* and *N. Macleanii*, where it attains a length of 3 cm. The effect of a large number of these plants in flower is very striking. This was well seen in the case of *N. turritella* (text-fig., p. 202), which grows in masses on the slopes of El Misti in Peru at an elevation of about 14,000 feet *.

The Stamens.—The stamens show the ordinary Malvaceous arrangement in a column, but two types are met with. In some species, particularly those from Ecuador, the anthers form a more or less elongated cylindrical head, and this is correlated almost invariably with the absence of a corolla tube (Pl. 30. fig. 9). In the majority of species, however, the anthers are arranged in a globose head (Pl. 30. fig. 6). The anthers may be yellow or purple. The free portions of the filaments are very short in some species and long in others.

A point of interest was noticed in connection with the two smallest perennial species *N. Azorella* and *N. congesta*, collected in the province of Sandia (Peru) by Weberbauer, since the flowers appear to be monœcious. The stamens, which are very few in number, in both species slightly exceed the corolla in length, and neither styles nor carpels were found in any of the flowers examined. It is impossible, however, from the material available to say whether the condition of these plants is normal or whether it may be due to their being the early flowers of the season (Pl. 28. fig. 15).

The Fruits.—The styles, usually 8–14 in number, are like those of the genus *Malvastrum*, A. Gray, in being capped with papillate stigmas.

The fruits are found to be of considerable systematic value, and it is unfortunate that ripe fruits of many of the species are not yet known.

Each carpel is more or less prolonged into a beak, and when ripe the carpel splits nearly to its base into two halves. The beak remains practically undeveloped in the annual species, and in some other cases it is very small, but it may attain a length of as much as 5 mm. (*cf.* Pl. 30. figs. 11–31).

The dorsal surface of the carpel including the beak is covered with hairs; in some

* *Cf.* Jameson's remarks about *N. pichinchensis*, p. 211.

species the hairs on the venter of the carpel and on the beak are similar, but in others the venter may be covered with small stellate hairs while the beak is beset by silky hairs, often very long and spirally twisted.

All kinds of stellate hairs are met with on the fruits, and the nature of these, together with the length of the beak, are of great value for the determination of the species.

The seeds in all cases are irregularly reniform and often show a longitudinal dorsal furrow (Pl. 30. figs. 19, 23, 32).

Geographical Distribution.

The range of the genus appears to extend from the high mountains of Antisana, Pichincha, &c., on the borders of Ecuador and Colombia, as far south as the cordillera of Santiago in Chile, with an eastern extension through the south of Bolivia into the provinces of Salta and La Rioja (Sierra Famatina) in Argentina.

The genus appears to reach its maximum development in the south of Peru and in Bolivia, but it is possible that a fuller knowledge of the flora of Northern Peru may necessitate a modification of this statement.

One curious and unexplained fact in connection with the geographical distribution of *Nototriche* is the sharply defined northern boundary in the mountains of Ecuador. No specimens have been collected north of Pichincha, although the cordillera in Colombia would appear to afford conditions as favourable for the growth of these plants as elsewhere in the range. It is possible that this marked break in the flora in the north of Ecuador may be apparent rather than real and may be due to the fact that the country lying on the boundary between Colombia and Ecuador has not yet been properly explored: for in the region of the "knot" of the cordillera, about 1° north of the Equator, where the triple ridge of the Colombian cordillera passes into the Cordillera occidental and oriental of Ecuador, there exists an area but little known to botanists and without doubt of great interest in connection with the relationship of the Colombian flora to that of the Andes of Peru and Bolivia.

From the tabular statement of the geographical distribution of the various species, which is placed at the end of this section, it will be seen that certain species appear to be confined to very restricted areas. In some cases no doubt they are very local in their occurrence, while in others our ignorance of the Andine flora in certain regions makes them appear so, and this applies more particularly to the Andes of Northern Peru and of Chili and Argentina.

As examples of species with a very restricted range the following may be cited: *N. turritella*, which appears to be confined to the slopes of the volcano El Misti (Dep. Arequipa), *N. argyllioides* from Vincocaya (Dep. Arequipa) and *N. sajamensis* which has been found only on the volcanoes of Sajama and Tacora. The species from the Atacama desert, from Ecuador, and several others are also very local.

On the other hand, several species, as can be seen from the Table, are known to have a considerably extended range: among these may be mentioned *N. flabellata*, *N. pedicularifolia*, *N. Mandoniana*, *N. Orbignyana*, *N. anthemidifolia*, and some others.

It is to be noticed that the species with the widest distribution have been collected in the neighbourhood of Lake Titicaca, and though they are found principally in the Eastern Cordillera of the Andes, specimens are also recorded in some cases from the Western Cordillera. One interesting case met with was that of *N. lanata*, which was found both in the peninsula of Copacabana (S.W. side of Lake Titicaca) and also on the hills above Huaycho on the N.E. shore, but in no other localities. In the vicinity of Lake Titicaca Nototriches are not found in the broad plain or Puna to the north and south of the Lake, but only on the hills forming the crests of the cordillera on either side and this broad alluvial valley stretching from the Nevado de Vilcanota in about lat. 12° 5′ S. to about 20° S. lat., including the Lakes Titicaca and Poopo, appears to act as a natural barrier separating the species of the Eastern from those of the Western Cordillera—so much so that only about five species have been recorded from both sides of this region. It is possible that these common species may have spread by way of the Vilcanota Mountains which block the head of the valley, or, as appears to have been the case with *N. lanata*, may have spread by way of the narrow straits of Tiquina, where the intervening water-way, which is bounded by high hills, may not in former times have been an insuperable barrier to distribution.

In the key to the genus, *vide* pp. 214–217, the various species have been grouped according to the cutting, lobation, and general configuration of the leaves, and an attempt has been made to show the relationships of the species to one another. There must, however, owing to the imperfection of the records, be considerable gaps in our knowledge, so that it is not possible in many cases to draw conclusions as to the affinities of certain species.

In order to show the parts of the Andes from which collections of *Nototriche* have been made, the localities, with their latitudes, for the various species have been set out in tabular form.

Ecuador (Antisana, Pichincha and Chimborazo, 0° 9′–1° 5′ S. lat.).
N. pichinchensis, N. phyllanthos, N. Jamesonii, N. Hartwegii, N. Lobbii (?).

Peru: **Dep. Cajamarca** (Hualgayoc, 6° 5′ S. lat.).
N. artemisioides.

Dep. Ancachs (Yungay, 9° S. lat.).
N. coccinea.
(Prov. Cajatambo, 10° 5′ S. lat.).
N. obtusa, N. pusilla, N. epileuca, N. longissima, N. argentea.

Dep. Lima (Cerro de Pasco, Oroya, 10° 5′–11° 5′ S. lat.).
N. Matthewsii, N. nigrescens, N. ulophylla, N. Macleanii, N. aretioides, N. stenopetala, N. Cavanillesii (?).

Dep. Apurimac (Andahuaylas, 13° 5′ S. lat.).
N. dissecta, N. Pearcei.

Dep. Puno (Prov. Sandia on the borders of Bolivia, 14° S. lat.).
N. Azorella, N. congesta, N. condensata, N. sulphurea, N. sericea, N. Mandoniana, N. acuminata.

Dep. Huancavelica (14° S. lat.).
N. Mandoniana.

Dep. Cuzco (13° 5′ S. lat.).
N. aristata, N. Castelnæana (? Dep. Lima), *N. longirostris.*

Dep. Ayacucho (13° 5′ S. lat.).
N. acuminata.

BOLIVIA: N.E. side of Lake Titicaca.
(14°–16° 5′ S. lat.) *N. pedicularifolia, N. flabellata, N. obcuneata, N. Orbignyana, N. longirostris, N. anthemidifolia, N. sulphurea.*
(16°–17° S. lat.) *N. purpurascens, N. Mandoniana, N. lanata, N. cinerea* (?).
(19° 5′ S. lat., Potosi.) *N. pygmæa, N. pedicularifolia, N. flabellata, N. Orbignyana.*

PERU: S.W. side of L. Titicaca. Dep. Puno, Dep. Arequipa (16°–16° 5′ S. lat.).
N. lanata, N. pedatiloba, N. turritella, N. argyllioides, N. pedicularifolia, N. Orbignyana.
Borderland of Peru, Bolivia and Chili (16° 5′–18° S. lat.).
N. pedicularifolia, N. anthemidifolia, N. borussica, N. Meyeni, N. alternata, N. sajamensis, N. obcuneata.

SOUTHERN BOLIVIA (? about 20° S. lat.).
N. pseudoglabra, N. glauca.

CHILI: Prov. Tarapaca (20°–23° S. lat.).
N. Philippii, N. rugosa, N. parviflora, N. auricoma, N. stipularis (?).
Prov. Atacama (25° 4′ S. lat.).
N. clandestina, N. megalorrhiza (?).

ARGENTINA: Prov. Jujuy (24° S. lat.).
N. anthemidifolia, N. Friesii.
Prov. Salta (25° S. lat.).
N. Lorentzii, N. saltensis.
Prov. La Rioja (29° S. lat.).
N. Niederleinii, N. famatinensis, N. Hieronymi, N. pulvillus.

ARGENTINA and CHILI: Cord. Santiago and Uspallata Pass (33° S. lat.).
N. compacta, N. transandina.

ALTITUDES.

All the species of this genus belong to the high alpine flora of the Andes; in the northern regions they are not found below about 3,900 m. and in Chili they only occur above an altitude of 2,500 m.

With regard to exact altitudes the information is somewhat meagre, but some definite measurements in connection with the flora have been made by Whymper, Conway, Fitzgerald, Fries, and others. Whymper collected plants of *N. phyllanthos* and *N. Jamesonii* in Ecuador, and found plants of the former species on Antisana at from 4,600 to 5,000 m.*

Conway's plants from the high Andes of Bolivia have been published in the Journal of the Linnean Society †, and it is worthy of note that *Nototriche flabellata* was the highest plant found by him; it occurred at an altitude of 5,640 m. (18,500 ft.), between the mountains Illimani and Illampu at about 16° S. lat.

In Ecuador, according to Whymper ‡ the line of permanent snow is somewhat variable, being as low as 14,300 ft. on some mountains, but from the data supplied it appears that the snow line may be considered to lie between 14,500–15,500 feet (4,420–

* Whymper, 'Travels amongst the Great Andes of the Equator,' pp. 199, 334, and 350–353, where this species is referred to as *N. phyllanthos.*

† Hemsley & Pearson, in Journ. Linn. Soc., Bot. vol. xxxv. (1901) p. 78–80.

‡ Whymper, *l. c.* pp. 346–348.

4,720 m.). On El Misti, an isolated volcanic cone rising behind the town of Arequipa to a height of 19,200 feet, the snow-cap may be very small or may extend from 1,000–2,000 feet below the summit. Here *N. turritella* was found up to an altitude of 16,400 feet (5,000 m.) and the species has a vertical range of 1,000 m. The highest record for any species of *Nototriche* is that given by Fries for the plant collected by him on the Nevado de Châni, Argentina, in 24° S. lat. His species, which I have called *N. Friesii*, was found at an altitude of 5,600–5,700 m., and Dr. Fries informs me that these figures are correct. The altitude to which these plants can reach appears to be to some extent dependent on the snow-line, though they may be found sometimes in protected crevices above the line at which permanent snow usually occurs. In the Nevado de Châni the line of permanent snow lies at about 5,800–5,900 m., but on the Illimani-Illampu chain, owing to the greater collecting-area and to the presence of glaciers, the snow-line appears to be between 5,000–5,500 m., though Conway does not give exact figures.

It seems somewhat surprising at first sight that the species reaching to the greatest altitudes should be found as far south as 24° S. lat., whilst those from Ecuador are found at lower elevations. The question is no doubt bound up with climatic conditions, and it is probable that the small rainfall and the small amount of permanent snow enable these plants to live at greater elevations in the southern districts.

In the south the greatest height recorded is for a plant which has been described as a new species under the name of *N. transandina*. This was found by Gosse in the upper valleys of Aconcagua, about 32·5° S. lat., at 3,650 m., and appears to be identical with the specimen collected by Moseley on the Uspallata Pass in the same latitude.

Soil.

With regard to the soil in which the Nototriches grow, very little information has been given by collectors.

A considerable number of species, especially those of Southern Bolivia and Peru, flourish in volcanic ash. On the volcanic ash of El Misti and in the neighbourhood of Vincocaya, *N. turritella* (text-fig., p. 202), *N. pedatiloba*, *N. Orbignyana*, *N. lanata*, *N. argyllioides*, *N. pedicularifolia*, and *N. sericea* are to be found. *N. borussica*, *N. Meyeni*, *N. alternata*, *N. sajamensis* also apparently flourish on the volcanic soil on the slopes of the mountains Tacora and Sajama. In such cases the plants form isolated patches or small cushions in the blackish-grey sandy ash, into which the roots penetrate to a considerable depth.

According to Fries, the Nevado de Châni, on which *N. Friesii* grows, is formed of granite, trachyte, and quartzite, the slopes being covered with stones, quartz, and sand, with a good deal of salt; and in the desert of Atacama, whence Philippi brought several species, the soil must be of a somewhat similar character.

Weberbauer is careful to give particulars of the habitats of the plants he collected, and in most cases the soil is stated to be poor and stony.

Speaking generally, it seems that the species with leaves of the palmatifid type prefer a poor dry soil, especially of a volcanic origin: it was noticeable, so far as I was able to observe on my own journey, that where a richer and deeper soil existed Nototriches were not to be found.

Some species, however, particularly those with bi-pinnatifid leaves, are found associated with grass and other plants, which form a general carpet on the more rocky soils; amongst such may be mentioned *N. longirostris*, which was found growing amongst patches of *Azorella*, and *N. aristata*, found in a rocky alpine valley covered with dwarf vegetation.

N. Mandoniana and *N. purpurascens* are said to grow in grass amongst rocks, and *N. artemisioides* and *N. acuminata* on grass steppes. It is unfortunate that information is so scanty as to the habitats of the various species, but it appears that those species which tend to form definite cushions are more likely to be found in bare rocky places, while those which are unbranched and form only a single rosette are more usually associated with grass and other plants.

N. pichinchensis, according to Jameson, "forms a sort of dense turf at an elevation of 15,000–16,000 feet, and from the beauty of its flowers enlivens in no small degree the gloomy aspect of the surrounding scenery."

A considerable amount of valuable information on the general vegetation and the climatic condition of the Peruvian Andes is given by Weberbauer *, including a careful account of the meteorology and of the soil temperatures. Various biological features of the high Andean vegetation, with an account of some of the formations and of their relation to the soil, are also discussed by him.

Collectors.

A short note on the numerous collectors and botanists who have travelled in the Andes and gathered the various species of *Nototriche* may not be out of place at this point †.

Amongst the earliest was the Abbé Cavanilles, who sent home plants from Quito which are now at Madrid. It is unfortunate that it has been found impossible to see these specimens or to obtain definite information about them. Humboldt and Bonpland in the same region collected *N. pichinchensis* and *N. phyllanthos*, &c., and our herbaria have been plentifully supplied from this part of Ecuador by the activity of Jameson, Spruce, Hartweg, Sodiro, and others.

To the south, in Bolivia, the earliest collections were made by D'Orbigny in the neighbourhood of Potosi, and by Meyen to the south of Lake Titicaca, but it is to Weddell, Mandon, and Richard Pearce ‡, one of Veitch's travellers, that we mainly owe our knowledge of this region. From the desert of Atacama, R. A. Philippi brought back several curious little species which appear to be confined to northern Chili, whilst Gay collected *N. compacta* in the Cordillera of Santiago, S. Chili, which appears to be the southern limit of the genus.

Hieronymus, Niederlein, and Lorentz discovered several species in the mountains of Northern Argentina, whence Fries has lately brought home some further specimens.

* Weberbauer, in Engl. Bot. Jahrb. xxxvii. pp. 60–94; ib. xxxix. pp. 449–461.

† Some interesting information concerning collectors in the Andes is given by Hemsley and Pearson in Journ. Linn. Soc., Bot. xxxv. (1901) pp. 78–79, in the introduction to their account of the plants collected in the Bolivian Andes by Sir Martin Conway.

‡ *Vide* 'Hortus Veitchii,' pp. 45–48.

In Peru there is much untravelled country and plants have been collected from spots more or less isolated. Around Lima, Pickering, of the United States Exploring Expedition, in 1840, collected some four or five new species, and some of these have never been sent home since. Considerable additions to our knowledge of this region were also made by Maclean, a merchant of Lima, and by Matthews. Of recent travellers, Weberbauer * has brought many new species to light, from the Andes near Oroya, from the province of Sandia on the borders of Peru and Bolivia, and from the department of Ancachs in Northern Peru. From this latter district he has collected some interesting forms which show affinity to the species of Ecuador.

On my own journey around Lake Titicaca and thence to Cuzco five new species of *Nototriche* were found. A few species collected by Copeland, though from the summit of the Puno railway, are all different from those which I hastily gathered in the same region—a fact which points to the great number of species of this genus which may be found in a small area. Fiebrig and also Steinmann have recently made journeys into S.W. Bolivia, and brought a few new species to our notice. The collection made by the latter has been described by Solms-Laubach †.

Concluding Remarks.

The diversity in the leaf-form, in the distribution and character of the tomentum, &c., exhibited by the species of the genus *Nototriche* make it difficult to believe that they represent in their varied forms an expression of adaptation to particular conditions of environment. Should it be held, however, that a given specific type appears to be more particularly adapted to its situation than another, it then becomes a matter of difficulty to explain the occurrence of several different species in close association on the same substratum ‡.

Another remarkable point in connection with the distribution of this genus is the extraordinarily local character of some of the species, to which allusion has already been made, since a single species may be confined to one particular and isolated area, where it exists as it were on an island cut off from its nearest allies.

From a consideration of these facts the conclusion is arrived at that the numerous specific forms partake of the nature of chance variations, sports, or mutations §.

Such mutations may have arisen in considerable numbers and have either persisted in their place of origin as a small local species showing fairly close resemblance to other forms, or they may have spread further afield into the domains of a species of a widely different type. As such mutants spread ever further from their point of origin they may in their turn have given rise to new and slightly differing races, and so have

* Weberbauer, in Engl. Bot. Jahrb. xxxvii. pp. 580–587.

† Solms-Laubach, in Bot. Zeit. 1907, pp. 119–138, taf. 2.

‡ E. g. *N. sericea*, *N. pedatiloba*, *N. argyllioides*, *N. Orbignyana*, and *N. pedicularifolia* were all collected at Vincocaya, and were growing in volcanic ash at about 14,600 ft. alt. The first three species were collected by myself within a few yards of each other, while the train stopped at Vincocaya station.

§ *Cf.* Solms-Laubach, in Bot. Zeit. 1907, pp. 130–131.

produced a chain of allied forms distributed over a fairly extended region. Others, again, once formed may have remained stable perhaps over a long period of time, and, by the intercalation of other unrelated species or perhaps by the dying out of those most nearly related to them, now appear as somewhat isolated and peculiar forms.

It is of course also highly probable that some species, though they show a resemblance in their leaf-form may not really be very closely related, but may represent the outcome of variations in the same direction on the part of two widely distinct ancestors.

From such a point of view it appears that the two contrasted leaf types, palmate and pinnate, may be regarded.

Taking a 5-lobed "palmate" leaf as the normal and original type of the lamina for the genus, it may be supposed that the evolution of the pinnate type has occurred by successive mutations from the palmate type in the direction of the enlargement and elongation of the median lobe. Then with the further progress of variation along the lines of the two established and divergent types, a number of curious and elaborate forms have arisen which in the intricate variety of their leaves appear to be due rather to the indulgence of exuberant fancy than to the outcome of any definite response to particular conditions.

Together with the variation in the leaves, floral and other variations would naturally have taken place, the expression of which can be seen in the presence or absence of a tube to the corolla, the arrangement of the stamens, and the shape and hairiness of the carpels.

The history of the course of events in the evolution of the species of the genus *Nototriche* may, however, be regarded from another standpoint. It has already been pointed out that the species may be arranged in two groups on the character of the presence or absence of a corolla-tube (p. 206). In ten species the corolla-tube is practically absent, nine of them showing the stamens arranged in an elongated head (Pl. 30. fig. 9), three other species show a similar cylindrical arrangement of the stamens but possess a more or less definite corolla-tube, and in three others though the corolla-tube is short, the stamens are arranged in a globose head, as in almost all the species where the corolla-tube is well marked * (Pl. 30. fig. 8).

* The species with the corolla-tube practically absent are tabulated below: where there is a short tube the length is stated:—

Corolla-tube none. Stamens in cylindrical head.	Corolla-tube none. Stamens in globose head.	Corolla-tube short. Stamens in globose head.
N. pichinchensis.	*N. flabellata.*	*N. condensata* (1–2 mm.).
N. phyllanthos.		*N. Orbignyana* (1–2 mm.).
N. Hartwegii.		*N. Lobbii* (2 mm.).
N. Macleanii.		
N. pedicularifolia.	**Corolla-tube present. Stamens in cylindrical head.**	
N. Lorentzii (?).		
N. Matthewsii.	*N. Jamesonii* (3–4 mm.).	
N. stenopetala.	*N. Pearcei* (2 mm.).	
N. epileuca.	*N. sulphurea* (1·5–2·5 mm.).	

Of the two groups so defined the smaller deserves more particular attention. Included in it are to be found species with every type of leaf-form, &c.; and though it is evident that from a consensus of characters a relationship exists between certain of the species, yet the position of the others is by no means clear. If, then, the character of the corolla is to be taken as a starting-point in the evolution of the species, it would appear that the independent appearance of similar leaf-forms in the two groups must be accounted for, and for this there does not seem at present to be sufficient evidence to warrant the assumption *.

It seems therefore to be of more value and also more within the limits of probability if in this genus the form of the leaf is regarded as affording a more certain indication of the relationships of the different species, and it is on this assumption that the following account of the genus *Nototriche* has been prepared.

THE GENUS NOTOTRICHE.

Nototriche, Turcz. emend. et ampl. A. W. Hill, in Engl. Bot. Jahrb. xxxvii. p. 578.

Species about 70, Andes of South America in Ecuador, Peru, Bolivia, Argentine to the cordillera of Rioja and Chili as far south as the cordillera of Santiago.

In Tropical South America between 3900 and 5700 m.; in Temperate South America above 2500 m.

Clavis Specierum.

Annuæ.

Lamina ambitu cordata vel orbicularis ; carpella minute birostrata . . . . . 1. *N. pusilla.*
Lamina ambitu reniformis vel flabelliformis; carpella rotundata . . . . 2. *N. pygmæa.*

Perennes.

Lamina minuta, integra, obovata . . . . 3. *N. clandestina.*
Lamina palmatifida, pinnatifida et varie dissecta.
  Lamina semicircularis vel reniformis plus minusve ad medium 5-lobata.
    Lamina supra stellato-tomentosa.
      Lamina plus minusve carnosula; corolla violacea . . . . 4. *N. Hieronymi.*
      Lamina coriacea; corolla coccinea . . . . 5. *N. coccinea.*
    Lamina supra et infra stellato-tomentosa.
      Lamina semicircularis, minuta, circa 3 mm. longa, 4 mm. lata; stipulæ late subulatæ membranaceæ . . . . 6. *N. Azorella.*
      Lamina herbacea, reniformis, multilobata; stipulæ subulatæ, herbaceæ . 7. *N. obtusa.*

---

* *N. Jamesonii* from this point of view would appear to be far removed from *N. phyllanthos*, &c., to which it appears on other grounds to be closely united. *N. pedicularifolia*, *N. Lorentzii*, and *N. sulphurea* would also be far removed from species to which on other grounds they appear to be closely allied. The other seven species in the first column of the footnote on p. 213, however, show certain points of similarity which may indicate a real alliance, though they appear to be strikingly different from the three species cited above.

Lamina carnosula, cuneata vel semicircularis; stipulæ filiformes, vel sæpius obsoletæ.

Lobi apice auricomi, breves, obovati, obtusi . . . . 8. *N. auricoma.*

Lobi oblongo-obtusi, inflexi . . . . 9. *N. compacta.*

Lamina ambitu plus minusve obovata vel cuneata ad medium 5-*lobata.*

Lamina minuta, 4 mm. lata . . . . 10. *N. congesta.*

Lamina circa 1 cm. lata.

Lamina supra et infra stellato-tomentosa.

Tomentum lanatum; corolla violacea . . . . 11. *N. Hartwegii.*

Tomentum velutinum; corolla punicea . . . . 12. *N. flabellata.*

Lamina supra dense infra sparse stellato-tomentosa.

Lobi obovati, obtusi . . . . 13. *N. nigrescens.*

Lobi lineari-oblongi, subacuti . . . . 14. *N. condensata.*

Lamina ambitu semicircularis vel reniformis flabellatim ad medium multilobata.

Lamina supra stellato-tomentosa.

Laminæ segmentis pinnatisecto-lobulatis.

Lobi laterales lobulis inflexis instructi . . . . 15. *N. ulophylla.*

Lobi laterales integri, inflexi.

Lacinuli late oblongi, obtusi; carpella 7 mm. longa, rostris 3 mm. longis . . . . 16. *N. obcuneata.*

Lacinuli anguste oblongi, obtusi; carpella 4–5, 5 mm. longa, rostris 1·5–2 mm. longis . . . . 17. *N. pulvilla.*

Laminæ segmentis profunde digitatim multilobulatis.

Stipulæ late truncatæ . . . . 34. *N. pedatilobata.*

Stipulæ filiformes . . . . 37. *N. sajamensis.*

[*Vide infra.* Formæ laminis profunde multisectis instructæ præsertim *N. alternata*, *N. turritella,* ad *N. sajamensem* similibus sed foliis supra et infra tomentosis.]

Lamina supra et infra stellato-tomentosa.

Stipulæ cum vagina facie et in dorso dense stellato-tomentosæ . . . . 18. *N. transandina.*

Stipulæ cum vagina facie et in dorso glabræ.

Lamina ambitu rotundata, lobulis congestis inflexis . . . . 19. *N. Friesii.*

Lamina ambitu triangularis, lobulis plus minusve planis . . . . . 20. *N. famatinensis.*

Lamina ambitu semicircularis vel quadrata, 5-*fida vel trifida.*

Lamina supra et infra dense stellato-tomentosa.

Tomentum velutinum, pilis stellatis brevibus.

Lamina ambitu triangularis, trifida, segmento medio elongato; stipulæ lineari-oblongæ, breves . . . . 21. *N. Jamesonii.*

Lamina ambitu plus minusve semicircularis, 5–7-fida, segmentis trilobatis; stipulæ filiformes, elongatæ.

Corolla violacea, tubo 5 mm. longo . . . . 22. *N. artemisioides.*

Corolla aurantiaca, tubo 2 mm. longo . . . . 23. *N. Lobbii.*

Tomentum lanatum, pilis stellatis longis . . . . 24. *N. lanata.*

Lamina supra dense stellato-tomentosa, infra coriacea, aliquanto sparse stellata.

Tomentum lanato-hirsutum; stipulæ supra tomentosæ.

Vagina plus minusve glabra . . . . 25. *N. Macleanii.*

Vagina spinosa . . . . 26. *N. aretioides.*

Tomentum velutino-stellatum; lamina infra coriacea; stipulæ supra glabræ vel subglabræ.

Lamina circa 1·8 cm. longa, 2·2 cm. lata; stipulæ subulatæ, 8–10 mm. longæ, petiolo supra medium adnatæ . . . . 27. *N. pichinchensis.*

Lamina 8–10 mm. longa, 1·0–1·3 cm. lata; stipulæ plus minusve triangulares, 3–4 mm. longæ, usque ad laminam adnatæ . . . . . 28. *N. phyllanthos.*

Lamina ambitu plus minusve semicircularis, profunde dissecta, segmentis in lacinulas multas sectis.

Segmenta laminæ longa, profunde secta.

Segmenta laminæ plus minusve acuta.

Tomentum velutinum . . . . 23. *N. Lobbii.*

Tomentum hirsutum.

Corolla purpurea, 1·0–1·2 cm. longa, basi tubo 2 mm. longo instructa . . . . 30. *N. Orbignyana.*

Corolla rosea, 1·7 cm. longa, basi tubo 6 mm. longo instructa . . . 31. *N. dissecta.*

Segmenta laminæ cuneata, brevia pauca.

Lamina supra et infra albo-velutino-tomentosa . . . . 29. *N. borussica.*

Lamina supra præsertim laxe hirsuta.

Lamina minuta, 2 mm. longa, 5 mm. lata; corolla rosea, circa 3·5 mm. longa . . . . 32. *N. parviflora.*

Lamina 5–6 mm. longa, 1·0 cm. lata; corolla albo-purpurea, 1·5 cm. longa . . . . 33. *N. Meyeni.*

Segmenta laminæ brevia, arcte congesta, numerosa.

Stipulæ oblongæ, obtusæ.

Stipulæ late truncatæ, cum vagina supra et infra glabræ . . . . . 34. *N. pedatilobata.*

Stipulæ lineari-oblongæ, obtusæ, cum vagina supra glabræ, infra dense tomentosæ . . . . 35. *N. turritella.*

Stipulæ filiformes.

Lamina ambitu late cuneata, circa 7-fida, 6–7 mm. lata . . . . . . 36. *N. alternata.*

Lamina ambitu reniformis, 9–11-fida, 1·0–1·2 cm. lata . . . . . . 37. *N. sajamensis.*

Lamina ambitu plus minusve ovata, quadrata vel cordata, palmatifida, lobis pinnatafidis demum bipinnatifidis.

Laminæ lobulis brevibus obtusis crispis; tomentum puberulum.

Lamina supra tomentosa, infra glabra vel sparsissime stellata.

Lamina circa 1 cm. longa, 1 cm. lata; corolla 7–8 mm. longa . . . 39. *N. rugosa.*

Lamina 1·5–2 cm. longa, 1·5–2 cm. lata; corolla 1·5–2 cm. longa.

Carpella circa 10, 7 mm. longa, dorso stellato-ciliata . . . . . . 41. *N. Niederleinii.*

Carpella circa 17, 5 mm. longa, dorso sericeo-ciliata . . . . . . 40. *N. argyllioides.*

Lamina supra et infra dense stellato-tomentosa.

Tomentum puberulum . . . . 38. *N. Philippii.*

Tomentum velutinum.

Lamina plus minusve bipinnatifida, lobulis cripis . . . . 42. *N. pedicularifolia.*

Lamina plus minusve palmatisecta . . . . 12. *N. flabellata.*

Tomentum strigoso-lano-stellatum.

Tomentum incanum . . . . 43. *N. Lorentzii.*

Tomentum sulphureum . . . . 44. *N. sulphurea.*

Laminæ segmentis plus minusve pinnatis, lobulis elongatis plus minusve acutis.

Corolla cærulea, basi in tubum vix coalita . . . . 45. *N. Matthewsii.*

Corolla cuprea, basi in tubum 3–4 mm. longum coalita . . . . . . 46. *N. purpurascens.*

Lamina ambitu plus minusve oblongo-ovata, bipinnatifida, supra stellato-tomentosa, infra plus minusve glabra, lacinulis apice sæpius ciliatis.

Vagina supra glabra.

Laminæ segmentis regulariter trifidis supra niveo-tomentosis; corolla sanguinea.

Corolla circa 1·7 cm. longa, petalis anguste spathulatis . . . . . 47. *N. stenopetala.*

Corolla circa 2·5 cm. longa, petalis obovato-oblongis . . . . . . 48. *N. epileuca.*

Laminæ segmentis irregulariter pinnatifidis, lacinulis apice ciliatis; corolla rosea vel violacea.

Stipulæ supra stellato-tomentosæ . . . . 53. *N. Pearcei.*

Stipulæ supra glabræ vel sparse ciliatæ.

Laminæ lacinulis lineari-oblongis obtusis . . . . 52. *N. aristata.*

Laminæ lacinulis anguste lineari-oblongis subacutis . . . . . 56. *N. longissima.*

Vagina supra plus minusve dense ciliata.

Laminæ sericeo-tomentosæ.

Laminæ multisectæ, lacinulis anguste linearibus obtusis . . . . . 61. *N. sericea.*

Laminæ segmentis paucis instructæ, lacinulis lineari-oblongis obtusis. 60. *N. acuminata.*

Laminæ laxe stellato-tomentosæ; tomentum sæpius caducum.

Laminæ 1·0–1·5 cm. longæ, ambitu lanceolatæ, lacinulis oblongo-obtusiusculis . . . . 49. *N. longirostris.*

Laminæ 2–3 cm. longæ, ambitu oblongæ, lacinulis obovato-oblongis subacutis . . . . 55. *N. saltensis.*

Laminæ ambitu plus minusve late triangulari-ovatæ, 1·5–2 cm. longæ, lacinulis obovatis subacutis . . . . 54. *N. pseudoglabra.*

Laminæ minute stellato-tomentosæ.

Corolla 1·0–1·2 cm. longa, basi in tubum 3 mm. longum coalita . . 51. *N. anthemidifolia.*

Corolla 1·5–2 cm. longa, basi in tubum 5 mm. longum coalita . . . 50. *N. Mandoniana.*

Lamina ambitu plus minusve oblongo-ovata, bipinnatifida, supra et infra dense puberulo-velutina vel longe sericeo-stellato-tomentosa.

Laminæ longe sericeo-tomentosæ . . . . 62. *N. argentea.*

Laminæ velutino-stellato-tomentosæ.

Lacinuli lineari-oblongi, obtusi, haud crispi . . . . 58. *N. Castelnæana.*

Lacinuli brevissimi, rotundati, crispi . . . . 42. *N. pedicularifolia.*

Laminæ puberulo-stellato-tomentosæ.

Lacinuli ovato-oblongi, acuti, apice piliferi . . . . 59. *N. cinerea.*

Lacinuli vel lobi late cuneati, marginibus involutis . . . . 57. *N. glauca.*

Species non satis notæ:—

Pinnatifidæ ...... { *Sida pinnata*, Cav. / *S. acaulis*, Cav. / *Malvastrum Cavanillesii*, Gray. }

Palmatilobatæ ... { *M. stipulare*, Phil. / *Sida megalorrhiza*, Phil. }

Annuæ.

1. Nototriche pusilla, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. 1906, p. 587.

Peru: South, Feb. and April 1847, *Weddell* (Herb. Mus. Paris.: Pl. 29. fig. 19); Dep. Ancachs, Prov. Cajatambo, Cordillera nigra prope Chonta, 4400 m., *Weberbauer*, 2788 (Herb. Berol.: Pl. 29. figs. 20, 21; Pl. 30. fig. 29).

The leaves are crowded in a terminal rosette; short, spreading, horizontal branches are given off, which in their turn bear rosettes of leaves with flowers (Pl. 29. figs. 19–21). The tomentum is dense and somewhat shaggy, distributed all over the plant. The carpels have minute beaks (Pl. 30. fig. 29).

2. Nototriche pygmæa, A. W. Hill.—*Annua* pusilla, cæspitosa, circa 4 cm. longa; radix tenuis; caudex sub 1 cm. longus, ramosus. *Folia* arcte aggregata, dense hirsuta; petiolus 4 mm. longus; stipulæ petiolo ad medium adnatæ et cum eo quasi vaginam minutam formantes, parte libera circiter 3 mm. longa subulata uti petiolus facie et in dorso stellato-tomentosa; lamina reniformis vel subflabelliformis, circiter 2 mm. longa, 3 mm. lata, inciso-crenata vel lobata, lobis 8–10, supra et infra dense stellato-tomentosa. *Flores* ad petiolum medium insidentes, breviter pedicellati. *Calyx* ad medium 5-lobus, circiter 4 mm. longus, lobis triangularibus dense tomentosis, undique sparse tomentosus. *Corolla* albo-plumbea, 3 mm. longa; petala obovata, basi in tubum circiter 1 mm. longum coalita. *Carpella* 7, rotundata, circiter 1 mm. longa, ad apicem minute stellato-hirsuta; semine reniformi omnino repleta.

Sida pygmæa, Remy, in Ann. Sc. Nat. sér. 3, viii. p. 238.

Malva pygmæa, Wedd. Chlor. And. ii. p. 274.

Malvastrum pygmæum, A. Gray in Bot. U.S. Expl. Exp. p. 150, in adnot.; Baker fil. in Journ. Bot. xxix. 1891, p. 167.

Bolivia: Laguna de Potosi, *D'Orbigny*, 1359 (Herb. Mus. Paris.: Pl. 29. figs. 22–24; Pl. 30. fig. 30).

The whole plant of this species is only about 4 cm. long (Pl. 29. fig. 22), and the leaves are so small and so densely hairy that it is difficult to see how deeply the lamina is lobed (Pl. 29. fig. 23). The fruit is without a beak and is entirely occupied by the reniform seed (Pl. 30. fig. 30). The small flowers (Pl. 29. fig. 24) appear to be white with a dark centre, and on D'Orbigny's label are described as "chiquito de flor blanca." This species and *N. pusilla* are the only two known annuals in the genus.

Perennes.

3. Nototriche clandestina, A. W. Hill.—*Fruticulus* depressus, cæspitosus, sæpius pulvinatus; caudex lignosus, firmus, ramosus. *Folia* arcte aggregata, luteo-tomentosa; petiolus circa 9 mm. longus; stipulæ petiolo plus minusve ad petiolum medium adnatæ et cum eo quasi vaginam membranaceam 2 mm. latam formantes, parte libera 5–7 mm. longa filiformi uti vagina facie glabra in dorso et ad margines

dense lanato-stellato-tomentosa; lamina spathulata vel plus minusve rotundata, integra, rarius paullo lobata, 3–4 mm. longa et lata, carnosula, supra et infra dense velutino-stellato-tomentosa. *Flores* fere axillares, imæ basi petioli insidentes, breviter pedicellati. *Calyx* fere ad medium 5-lobus, 1 cm. longus, extus infra lanato-stellato-tomentosus, lobis triangulari-ovatis velutinis, intus glaber. *Corolla* albicans, sub 1 cm. longa. *Carpella* non visa.

Sida clandestina, Phil. in Flor. Atacama, p. 11.

Malvastrum clandestinum, Baker fil. in Journ. Bot. xxix. 1891, p. 363; Reiche, Fl. Chile, i. p. 234.

CHILI: Prov. Atacama, vallée Sandon, 25° 4′ S. lat., 3000 m., *Philippi*, 86 (Herb. Berol.: Pl. 28. fig. 3).

The small spathulate or obovate leaves (Pl. 28. fig. 3) in this interesting little species are entire by reduction. In some cases the lamina shows a slight lobation at the apex. As regards the tomentum and general colour, this plant is similar to *N. compacta*; and it is possible that this species may be its closest ally. The stipules are filiform and are often not well developed, as is also the case in that species, and one of them is frequently found to be adnate to a greater distance along the petiole than the other. The caudex appears to branch somewhat above the level of the ground (cf. *N. compacta*, *N. auricoma*). The whole plant is covered by a yellowish tomentum.

4. NOTOTRICHE HIERONYMI, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. 1906, p. 581.

ARGENTINA: Prov. Rioja, Pendientes de Nevado de la Famatina et Cueva de Perez, *Hieronymus et Niederlein*, 853 (Pl. 28. fig. 5).

The whole plant is slender, forming small rosettes. The leaf lobulæ are somewhat fleshy, slightly superposed (Pl. 28. fig. 5) and covered with a dense powdery tomentum of small stellate hairs.

5. NOTOTRICHE COCCINEA, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. 1906, p. 583.

PERU: Dep. Ancachs, supra lacum Yanganucos prope Yungay, 4600 m., *Weberbauer*, 3276 (Herb. Berol.: Pl. 30. fig. 17).

A densely branched species, with slender and often somewhat long branches forming a compact cushion; the root-system is much divided. The reniform leaf lamina shows some resemblance to that of *N. obcuneata*. The scarlet corolla is a peculiar feature of the species, and the petals are irregularly emarginate, having at the apex a large and a small subacute point. The carpels are covered with stellate hairs only (Pl. 30. fig. 17).

6. NOTOTRICHE AZORELLA, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. 1906, p. 582.

PERU: Dep. Puno, prov. Sandia, inter Poto et Ananca, 4600–4700 m., *Weberbauer*, 957 (Herb. Berol.: Pl. 27. fig. 3; Pl. 28. fig. 15).

N. Azorella and *N. congesta* (p. 221) are the two smallest perennial species which have yet been found. They both form small hard cushions, like those of the genus *Azorella*,

some 10 cm. in diameter, formed by the close association of the numerous more or less vertical branches of the caudex (Pl. **27.** fig. 3). The leaves are arranged in dense cylinders of about 1 cm. in diameter, and only those at the surface of the cushion are in a living condition. The centre of each tiny rosette is occupied by a flower. The specimens of both these species brought home by Weberbauer are peculiar in that the flowers appear to be unisexual, neither carpels nor their rudiments having been found. The corollas are about 6–7 mm. long, with a basal tube and a small head of stamens (Pl. **28.** fig. 15).

N. Azorella is easily distinguished from *N. congesta* by its rounded semicircular laminæ, by the broad vaginæ, and by the free parts of the stipules being broader and shorter than in *N. congesta* (Pl. **28.** fig. 15). In the latter species the leaf-laminæ are rather four-angled in outline, and they form a larger and less dense mass than in *N. Azorella*; the stipules also are filiform-subulate and acute. The upper parts of the branches are covered by the old dead leaves, and lower down only the vaginæ remain, which are covered with bristle-like stellate hairs on their outer sides. Large orange-coloured, glandular nectaries are seen at the base of the calyx (Pl. **30.** fig. 3).

7. Nototriche obtusa, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. 1906, p. 583.

Peru: Dep. Ancachs, Prov. Cajatambo, Cordillera supra Pisca-paccha, 4500–4600 m., *Weberbauer*, 2897 (Herb. Berol.).

This species shows fairly close resemblance to *N. artemisioides* (*q. v.* p. 228). The nectary-glands are figured (Pl. **30.** figs. 2, 4).

8. Nototriche auricoma, A. W. Hill.—*Fruticulus* depressus, cæspitosus, pulvinatus, breviter caulescens; caudex ramosus. *Folia* aggregata, incano-auricoma; petiolus circa 1 cm. longus, utrinque dense incano-stellato-tomentosa; stipulæ imperfectæ; lamina late cuneata, flabelliformis, ad medium 5-secta, 5–6 mm. longa, 10 mm. lata, supra et infra dense incano-stellato-tomentosa, segmentis plus minusve trilobis, segmento medio 3–5-lobato, lobis brevibus obovatis obtusis carnosulis supra auricomis. *Flores* fere ad petiolum medium insidentes. *Calyx* supra medium 5-lobus, circa 9 mm. longus, extra stellato-tomentosus, lobis triangulari-obtusis circa 3 mm. longis apice carnosulis auricomis intus tomentosis. *Corolla* lutea, circa 1 cm. longa; petala ovato-cuneata, unguiculata, retusa, basi in tubum circa 2 mm. longum coalita. *Carpella* 6–8, matura non visa.

Malvastrum auricomum, Phil. in Herb. Kew. ined.; Baker fil. in Journ. Bot. xxix. 1891, p. 365; Phil. Viaje à la Prov. Tarapacà, p. 8. no. 89; Reiche, Fl. Chile, i. p. 235.

Chili: Desert of Atacama, *Philippi* (Herb. Kew.).

This species forms little cushions of about 3 cm. in diameter; the caudex, which is fairly slender, apparently branches to a certain extent above ground. The stipules as a rule are not properly developed.

N. auricoma differs from all other species in having orange tips to the leaf-lobulæ and calyx-teeth. It is further distinguished by possessing yellow flowers, which are uncommon in the genus.

9. Nototriche compacta, A. W. Hill.—*Fruticulus* depressus, dense cæspitosus, pulvinatus, incano-tomentosus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* arcte aggregata, imbricata; petiolus 6–8 mm. longus; stipulæ, in foliis floriferis, petiolo supra medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera filiformis vel subulata ad 5 mm. longa, in foliis non floriferis sæpius imperfecta, utrinque incano-lanato-stellato-tomentosa; lamina ambitu semicircularis vel reniformis, carnosula, trifida vel palmatim 5-fida, rarius 7-fida, circa 6 mm. longa, 9 mm. lata, utrinque dense lanato-tomentosa, segmentis integris vel raro 3–5-lobis, lobis obovato-obtusis inflexis. *Flores* supra petiolum medium insidentes, breviter pedicellati. *Calyx* urceolatus, fere ad medium 5-lobus, circa 7 mm. longus, extus dense tomentosus, intus glaber, lobis late ovato-triangularibus subacutis. *Corolla* cærulea, circa 1 cm. longa; petala obovata, rotundata vel truncata, basi in tubum circa 4 mm. longum coalita. *Carpella* 6–10, birostrata, 6 mm. longa, rostris 1·5 mm. longis, dorso superne stellato-ciliata, inferne stellato-tomentosa.

Sida compacta, Gay, Fl. Chile, i. p. 329.

Malvastrum compactum, A. Gray, in Bot. U.S. Expl. Exp. i. 1854, p. 152; Wedd. Chlor. And. ii. p. 279, t. 80. b; Baker fil. in Journ. Bot. xxix. 1891, p. 363; Reiche, Fl. Chile, i. p. 236.

Chili: Cord. Santiago, 3300 m., *M. Gay* (1846); Cajon de Mapocho, higher parts of Cord. Polvadera, 3100 m., *Gay* (Herb. Kew.).

This species and *N. transandina* (p. 226) are found at the extreme south of the range of the genus. *N. compacta* is perhaps more nearly related to *N. Hieronymi* from the Argentine (p. 219), but it is readily distinguished by the smaller number of the leaf-lobes, which are relatively large and obovate. The lamina appears to be trifid, but is 5–7-fid owing to the strong development of the lateral segments. A dense white woolly tomentum covers the whole plant (*v.* Wedd. Chl. And. ii. t. 80. b). The stipules of the vegetative leaves are often undeveloped (cf. *N. clandestina*, p. 218, *N. auricoma*, p. 220). This species forms dense and hard woolly cushions, and the caudices appear to branch somewhat above ground. The corolla is said to be blue, and according to Reiche an intense blue. The ripe carpels, which are large and woody, with the beaks forming only about $\frac{1}{4}$ of the length of the whole, form a very good specific character.

10. Nototriche congesta, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. 1906, p. 582.

Peru: Prov. Sandia, Suchez, 4500 m., *Weberbauer*, 1018 (Herb. Berol.).

Some notes on this species are given under *N. Azorella*, p. 219.

11. Nototriche Hartwegii, A. W. Hill.—*Fruticulus* depressus, cæspitosus, pulvinatus, lanatus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* in caput subglobosum circa 4–5 cm. diametro congesta, imbricata, persistentia; petiolus ad 2 cm. longus; stipulæ petiolo supra medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera membranacea lineari-acuta 5–7 mm. longa uti petiolus et vagina facie et ad margines dense in dorso sparse stellato-tomentosa; lamina ambitu late cuneata vel flabellatim cuneata, ultra medium trisecta, circa

9–12 mm. longa, 10–12 mm. lata, segmentis apice trisectis, lacinulis oblongis subacutis supra dense lanato-stellato-tomentosa, infra plus minusve dense vel sparse stellato-tomentosa. *Flores* circiter ad petiolum medium insidentes. *Calyx* ad medium 5-lobus, 1·5–1·7 cm. longus, extra lanato-stellato-tomentosus. *Corolla* violacea, 2–5 cm. longa; petala basi in tubum vix coalita. *Stamina* in columnam cylindricam elongatam instructa. *Carpella* circa 12, matura non visa.

Malvastrum phyllanthos, A. Gray, in Benth. Pl. Hartweg. p. 164; Wedd. Chl. And. ii. p. 278 (partim).

ECUADOR: Monte Assuay ad Las Cruces, 4550 m., *Hartweg*, 918 (Herb. Kew., Pl. 29. fig. 14; Herb. Mus. Brit., Herb. Paris., Herb. Univ. Cantab.); Quito, *Jameson* (Herb. Kew.).

N. Hartwegii, which has previously been confused with *N. phyllanthos*, is one of the most striking species of the genus. The stout branches covered with their closely compacted leaves form cylinders of 4–5 cm. in diameter. The cuneate leaves (Pl. 29. fig. 14) are covered on the upper surface with a dense woolly tomentum. The corolla, which is almost polypetalous, is 2·5 cm. long, and the stamens are arranged in an elongated column.

12. NOTOTRICHE FLABELLATA, A. W. Hill, descr. emend.—*Fruticulus* depressus, cæspitosus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* rosulata, canescentia; petiolus 2–4 cm. longus; stipulæ petiolo supra medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera membranacea lineari-subulata acuta circa 1 cm. longa uti petiolus facie et in dorso dense floccoso-stellato-velutina; lamina late obovato-cuneata ad rotundata, flabellatim 5- vel 7-fida, circa 1·5 cm. longa, 1·2–1·5 cm. lata, supra et infra floccoso-stellato-velutina, segmentis lateralibus ambitu obovato-cuneatis 5–7, inæqualiter inciso-crenatis inflexis segmento medio plus minusve trifido, lobis inciso-crenatis inflexis. *Flores* fere ad petiolum medium insidentes. *Calyx* ad medium 5-lobus, circa 1·8 cm. longus, lobis triangulari-acutis, extus floccoso-velutinus, intus glaber. *Corolla* punicea, 2–2·5 cm. longa; petala oblonga, unguiculata, 7 mm. lata, apice irregulariter retusa, basi in tubum vix coalita. *Stamina* in caput globosum instructa, exserta, columna circa 2·7 cm. longa. *Carpella* 9 mm. longa, birostrata, dorso stellata, rostris circa 5 mm. longis (in Lechler, 1972, partim), carpella fere matura 7·5 mm. longa, birostrata, inferne stellata, superne stellato-ciliata, rostris circa 2·5 mm. longis (in Weberbauer, 1005).

Malvastrum flabellatum, Wedd. Chl. And. ii. p. 281.

Malvastrum flabellatum, Wedd. in Bull. Soc. Bot. Fr. xii. p. 82; Hemsley & Pearson, in Journ. Linn. Soc., Bot. xxxv. (1901) p. 84; Baker fil. in Journ. Bot. xxix. 1891, p. 363.

BOLIVIA: Illimani, foot of the glaciers, *Pentland*; summit of Cord. of La Paz, *D'Orbigny*, 332 (altered from "232," *Althea*); prope Sorata, *Mandon*, 798 (Herb. Mus. Paris.); Suchez, near Peruvian province of Sandia, 4500 m., *Weberbauer*, 1005. (Herb. Berol.); Cord. Real, between Illimani and Illampu, 5640 m., *Conway*, 35; Huayna Potosi, Franz Joseph Glacier, 4900–5200 m., *F. Germann*, 10 (Herb. Bot. Mus. Hamburg.); Cord. Andacabá, near Potosi, 5200 m., *Steinmann*.

PERU: Prov. Carabaya, nr. Ayapata, *Lechler*, 1972, partim (Herb. Mus. Paris.: Pl. 30. fig. 14). Prov. Sandia, between Poto and Ananca, 4400–4500 m., *Weberbauer*, 961 (Herb. Berol.: Pl. 29. fig. 2; Pl. 30. figs. 7, 8).

Some difficulty exists as to whether all the specimens placed under *N. flabellata* really belong to the species as defined by Weddell; he himself saw no flowers, though one of the types at Paris, D'Orbigny's specimen from La Paz, no. 332, is inscribed "Fleur violette et peu apparante." It was owing no doubt to this note by D'Orbigny that Weddell added "floribus parvis parumque conspicuis" to his description of *M. flabellatum*. Yet Mandon's specimen, no. 798, with conspicuous crimson flowers, has been labelled *M. flabellatum* *, Wedd., by Weddell in the Paris Herbarium. In addition to this a sheet bearing the no. 1972, Lechler, at Paris, has been inscribed by Weddell "parte videtur *M. flabellatum* rostri fruct. longiss." And externally this plant is very similar to the type sheets of Pentland and D'Orbigny. Some complication arises with regard to this number of Lechler; for according to Weddell (*l. c.* p. 273) Lechler, 1972, =*M. phyllanthos*, whilst according to Baker fil. in Journ. Bot. xxix. p. 363, Lechler 1972 at Kew is the type of his *M. condensatum*.

Further, it is also possible that Turczaninow's *Nototriche incana* (D'Orbigny, 1353), of which no specimen could be found at Paris, is *M. flabellatum*, Wedd., though it is more probable that it is equivalent to *M. pedicularifolium*, A. Gray.

N. flabellata was one of the highest plants collected by Conway at 18,500 ft. The plant is very distinct, both from the sulphur-coloured velvety tomentum and from the crimson, almost tubeless corollas. The stamens are arranged in a globular head and the elongated column is exserted (*v.* Pl. 30. figs. 7, 8). The petals are irregularly toothed at the apex. The body of the carpel is covered with short stellate hairs, and the beak is ciliate (Pl. 30. figs. 14, 21). The leaf-lamina is also characteristic, the lower half forming a cuneate expansion, the divisions of the segments only reaching to the middle of the lamina. In some cases the segments only occupy $\frac{1}{3}$ of the length of the lamina (Pl. 29. fig. 2). As regards leaf-form *N. flabellata* shows alliance with *N. pedicularifolia*, *N. argyllioides*, &c., and in its tubeless corolla it agrees with *N. pedicularifolia*, *N. Lorentzii*, and *N. sulphurea*.

N. flabellata may perhaps be considered to be a species which, judging from the diversity of its leaf-form, is in a somewhat transitional condition and shows forms breaking away from the type.

13. NOTOTRICHE NIGRESCENS, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. 1906, p. 580.

PERU: Dep. Lima, "Hacienda" Arapa, prope Yauli, ad Lima-Oroya viam ferream, 4400 m., *Weberbauer*, 381 (Herb. Berol.).

The numerous stamens are arranged in a globose head, with the free portions of the filaments fairly long. The anthers are a dark purple-green.

The leaf-lamina is only sparsely stellate below and in its lobation shows some

* Bull. Soc. Bot. France, xii. 1865, p. 82. This determination of Mandon's plant was made after the publication of the 'Chloris Andina.'

resemblance to that of *N. flabellata.* The older petioles and backs of the leaves become black in the dried specimens.

14. Nototriche condensata, A. W. Hill.—*Fruticulus* depressus, cæspitosus, pulvinatus; caudex subterraneus, lignosus, crassus, ramosus. *Folia* aggregata; petiolus ad 2 cm. longus; stipulæ petiolo circiter ad medium adnatæ et cum eo quasi vaginam membranaceam 3–4 mm. latam formantes, parte libera lineari-acuta circa 1 cm. longa, uti petiolus facie et ad margines sparse stellata in dorso glabra; lamina late cuneata, flabelliformis, ultra medium 5–7-secta, circa 1 cm. longa, 1–1·2 cm. lata, supra dense incano-stellato-tomentosa, infra plus minusve sparse stellato-tomentosa, segmentis mediis 3–5-lobis. *Flores* paullo sub medio petiolo insidentes. *Calyx* fere ad medium 5-lobus, circa 1·3 cm. longus, plus minusve dense stellato-tomentosus, lobis triangulari-ovatis subacutis intus propter margines tomentosis. *Corolla* nigro-cærulea, 2·5 cm. longa; petala obovata-oblonga, unguiculata, emarginata, basi in tubum brevissimum 1–2 mm. longum coalita. *Stamina* in caput globosum instructa, filamentorum partibus liberis longis. *Carpella* 7 mm. longa, birostrata, dorso inferne stellato-tomentosa, rostris 3 mm. longis stellato-ciliatis.

Malvastrum condensatum, Baker fil. in Journ. Bot. xxix. 1891, p. 363.
Malvastrum phyllanthus, Wedd. Chl. And. ii. p. 278 (partim).

Peru: without precise locality, *Lechler*, 1972 (Herb. Kew.); Dep. Puno, Prov. Carabaya, near Ayapata, *Lechler*, 1972 partim (Herb. Mus. Paris.).

The lamina is very like the palm of a hand with finger-like lobes, some of which bear minute incurved lateral lobulæ. The corolla appears to be a deep blue. The corolla-tube is very short in this species, and the stamens are arranged in a globose head with the free portions of the filaments elongated.

15. Nototriche ulophylla, A. W. Hill.—*Fruticulus* depressus, cæspitosus; caudex subterraneus, crassus, ramosus. *Folia* arcte aggregata; petiolus ad 1·2 cm. longus; stipulæ petiolo circiter ad medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera late lineari-subacuta circa 6 mm. longa, facie et in dorso fere glabra ad margines stellata; lamina reniformi-rotundata, flabellatim ad medium 7–11-secta, circa 5–6 mm. longa, 8–10 mm. lata, supra incano-stellato-tomentosa, infra glabella, segmentis 3–7-lobis confertissimis, lobulis obovatis involutis quasi crispis. *Flores* ad petiolum medium insidentes. *Calyx* ad medium 5-lobus, 6 mm. longus, lobis triangulari-ovatis obtusis sparsissime stellatis. *Corolla* 6–7 mm. longa; petala obovata. *Carpella* 8, circa 1·5 mm. longa, matura non visa, minute birostrata, dorso dense sericeo-hirsuta (pilis 3–4 mm. longis).

Malvastrum ulophyllum, A. Gray, in Bot. U.S. Expl. Exp. i. 1854, p. 150.
Malvastrum ulophyllum, Wedd. Chlor. And. ii. p. 280 (partim); Hieron., in Engl. Bot. Jahrb. xx. Beibl. n. 49, p. 43 (partim); Baker fil. Journ. Bot. xxix. 1891, p. 364 (partim).

Peru: Andes of Alpamarca, near the snow-line, *Pickering* (Herb. Gray: Pl. 28. fig. 1).

A great deal of confusion has existed with regard to this species, since Weddell has

named a specimen *Malvastrum ulophyllum*, A. Gray—No. 4394 in Herb. Mus. Paris. (Pl. 27. fig. 6)—collected between Puno and Arequipa, without having seen Gray's type (*v.* Wedd. *l. c.* p. 280), and in his diagnosis in the 'Chloris Andina,' whilst keeping Gray's description of the species for the most part, he has added certain measurements belonging to his no. 4394. Through the kindness of Count Solms-Laubach I have been able to examine a leaf and flower of Gray's type, which was sent to him from Harvard; and from this the drawing of *N. ulophylla* (Pl. 28. fig. 1) has been made. Weddell's no. 4394 from South Peru is a very distinct plant, as the great difference in the localities had already suggested, and it agrees exactly with one of my own specimens (no. 80) collected in the same neighbourhood, of which I have made a new species, *N. argyllioides* (Pl. 27. fig. 7). Copeland's plant, also from Vincocaya, published as *M. ulophyllum*, Gray, in Engl. Bot. Jahrb. xx. Beibl. no. 49, p. 43, also belongs to this new species.

The true *N. ulophylla* is very closely allied to *N. obcuneata*, but it differs from that species in having longer lateral or secondary lobulæ, which are often again lobed, and the whole lamina has a very crisped appearance. It also differs in the smaller flowers and probably in the fruit, though the material of *N. ulophylla* was not in a sufficiently advanced stage to make certain on this point.

16. NOTOTRICHE OBCUNEATA, A. W. Hill.—*Fruticulus* depressus, cæspitosus, pulvinatus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* arcte aggregata, purpureo-cinerea; petiolus 1–2 cm. longus; stipulæ petiolo supra medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera membranacea lineari-acuminata circa 7 mm. longa uti petiolus facie et in dorso glabra ad margines stellata; lamina ambitu semicircularis vel reniformis, flabellatim 9–13-secta, 4–6 mm. longa, 8–9 mm. lata, supra dense cinereo-stellato-tomentosa, infra fere glabra, segmentis 3–7-lobis, lobis obovatis crenatis vel spathulatis inflexis. *Flores* fere ad petiolum medium insidentes. *Calyx* campanulatus, ad medium 5-lobus, circa 1·1 cm. longus, lobis triangularibus, extra stellato-tomentosus. *Corolla* in sicco violacea, ad 2 cm. longa; petala obovata vel obcuneata, unguiculata, retusa, basi in tubum 5 mm. longum coalita. *Carpella* 8–10, circa 7 mm. longa, birostrata, rostris circa 3 mm. longis, dorso stellato-hirsuta.

Malvastrum obcuneatum, Baker fil. in Journ. Bot. xxix. 1891, p. 363.
Malvastrum sajamensis, Hieron. partim, in Engl. Bot. Jahrb. xxi. p. 319.
Malvastrum lobulatum, Wedd. (Mandon, 799) in Bull. Soc. Bot. Fr. xii. 1865, p. 82.

BOLIVIA: prope La Paz, via ad Coroico, *Mandon*, 799 (Herb. Kew., Herb. Brit. Mus.); Sajama, 4800 m., *Stübel*, 5 ii. (Herb. Berol.); near La Paz, 3600 m., *Rusby*, 1373; Andes of Pelechuco, 4850 m., *R. Pearce* (Herb. Brit. Mus.); Huayna Potosi, Franz Joseph Glacier, 4900–5200 m., *F. Germann*, 11 (Herb. Mus. Bot. Hamburg.).
PERU: Prov. Sandia, Poto, 4400–4500 m., *Weberbauer*, 983 (Pl. 28. fig. 2); Ananca, 4700 m., *Weberbauer*, 1023 A (Herb. Berol.).

The lamina is very characteristic, semicircular with numerous segments, most of which bear incurved lateral lobes (Pl. 28. fig. 2). The upper surface of the lamina is covered with short many-rayed stellate hairs. According to Pearce, the flowers are

violet, but Weberbauer says of his plants that they were at first rose becoming white.

According to Pearce, this species was half buried in dry gravelly soil on steep slopes. (Herb. Brit. Mus.)

17. NOTOTRICHE PULVILLA (sphalm. PULVILLUS), A. W. Hill, in Engl. Bot. Jahrb. xxxvii. 1906, p. 581.

ARGENTINA: Prov. Rioja, Sierra Famatina, Cuesta del Tocino, *Hieronymus et Niederlein*, 688 (Pl. 28. fig. 4).

This species shows affinities to *N. obcuneata* in the general form of the lamina and in the tomentum, though in *N. pulvilla* all the parts are much smaller and the median lobe is characteristically trilobed at the apex (Pl. 28. fig. 4); the calyx and carpels also show important specific differences. The leaves show some resemblance to the young leaves of *N. sajamensis*, since the lateral lobulæ of the leaf-lobes grow up to form little bunches somewhat as in that species.

There seems to be a fairly close alliance between this species and *N. obcuneata*, *N. famatinensis*, *N. transandina*, and *N. Friesii*.

18. NOTOTRICHE TRANSANDINA, A. W. Hill.—*Fruticulus* depressus, cæspitosus, pulvinatus; caudex subterraneus, lignosus, firmus, crassissimus, ramosus. *Folia* arcte aggregata, cinerea; petiolus 1·5 cm. longus; stipulæ petiolo plus minusve ad medium adnatæ et cum eo quasi vaginam membranaceam 3–4 mm. latam formantes, parte libera subulata 5 mm. longa in foliis floriferis filiformi circa 1 cm. longa uti petiolus et vagina facie et in dorso stellato-tomentosa; lamina plus minusve semicircularis, circa 8 mm. longa, 9 mm. lata, fere ad medium flabellatim 9–11-secta, supra et infra dense stellato-tomentosa; segmentis integris vel 3–9-lobis; lobis obtusis confertis crispis. *Flores* breviter pedicellatæ, prope basin petioli adnatæ. *Calyx* circa 9 mm. longus, ad medium 5-lobus, lobis triangulari-acutis, stellato-tomentosus. *Corolla* circa 1·1 cm. longa; petala rotundato-obovata, unguiculata, truncata vel retusa, basi in tubum circa 3 mm. longum coalita. *Carpella* circa 10, 7 mm. longa, birostrata, rostris 3 mm. longis, dorso stellato-ciliata.

ARGENTINA: Prov. Mendoza, St. Rosa de los Andes to Uspallata Pass, 3650 m., *Moseley*, 'Challenger' Expedition; Upper valleys, Aconcagua, *P. H. Gosse*, Fitzgerald Expedition (Herb. Kew.).

19. NOTOTRICHE FRIESII, A. W. Hill.—*Fruticulus* depressus, cæspitosus, sæpius pulvinatus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* arcte aggregata, cinereoviridia; petiolus circa 1 cm. longus; stipulæ petiolo supra medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera membranacea lineari-acuta 6 mm. longa uti petiolus facie et in dorso glabra vel sparse tomentosa ad margines plus minusve stellato-pilosa; lamina flabellata, trifida, circa 6 mm. longa, 1–1·2 cm. lata, supra dense infra laxe stellato-tomentosa vel glabra, segmentis ambitu plus minusve quadratis 7–9-fidis vel lobis, lobis carnosulis inflexis integris vel 3–5-lobulatis obovatis crenatis. *Flores* ad petiolum medium insidentes. *Calyx*

fere ad medium 5-lobus, lobis obovato-oblongis acutis, circa 9 mm. longus, extra plus minusve glaber, lobis intra stellato-tomentosis. *Corolla* alba, circa 1·2 cm. longa; petala obovata, retusa. *Carpella* matura non visa.

Malvastrum obcuneatum, Baker fil. det. K. Schumann, in Nov. Act. Reg. Soc. Sc. Upsaliensis, ser. 4, vol. i. no. 1, p. 127.

Argentina: Prov. Jujuy, Nevado de Châni inter Saxa, 5600–5700 m., *R. E. Fries*, 360 (Mus. Bot. Stockholm.).

In this species, as in many others with much-lobed leaves, the lamina is really trifid, but owing to the strong development of the lateral segments it appears to be multilobed.

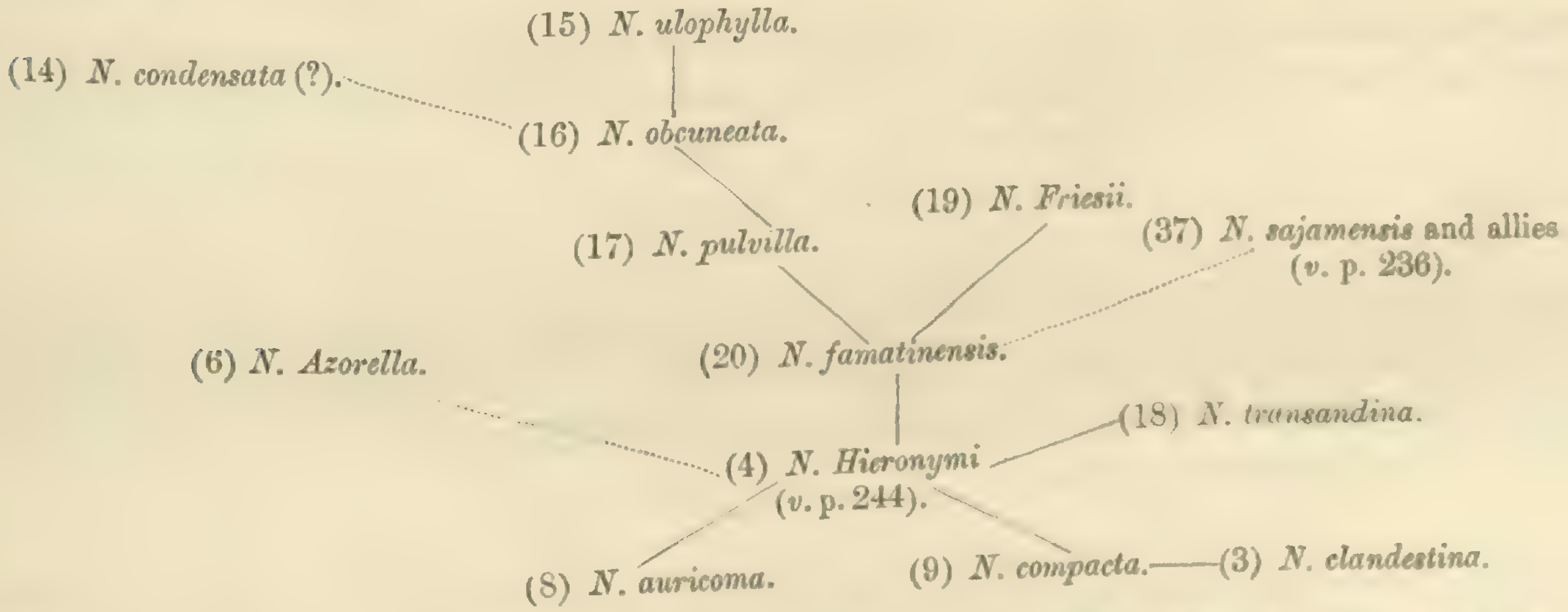
In the arrangement and shape of the leaf-lobes *N. Friesii* shows relationships to *N. obcuneata*, *N. ulophylla*, *N. transandina*, *N. pulvilla*, and *N. famatinensis*; but it is distinguished by the very regularly curved margin of its lamina, due to the fact that the small densely crowded lobulæ are all of about the same length. The more or less transversely oval outline of the lamina is also characteristic of this species. This species and *N. flabellata*, collected by Conway, occur at the greatest altitudes as yet recorded for the genus.

20. Nototriche famatinensis, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. 1906, p. 581.

Argentina: Prov. Rioja, Sierra Famatina, En las Vercanias de la mina Yareta, *Hieronymus et Niederlein*, 814 (Pl. 28. fig. 7).

The caudex in this specimen measured 2 cm. in diameter and 22 cm. in length to the commencement of the root-forking. The "cushion" was 4·5 cm. in diameter. A figure of the leaf is given (Pl. 28. fig. 7).

In the following diagram an attempt has been made to give a graphic representation of the probable relationships of some of the more obviously related species already described:—



Of the other species described in the preceding pages, *N. flabellata* appears to be more nearly allied to the species of the *pedicularifolia* group (*v.* p. 244), while *N. condensata*, *N. nigrescens*, *N. Hartwegii*, *N. coccinea*, and *N. obtusa* seem to have their nearest allies with *N. phyllanthos* &c. (*v.* p. 235).

21. Nototriche Jamesonii, A. W. Hill.—*Fruticulus* depressus, cæspitosus, sæpius pulvinatus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* aliquando repanda, cinerea; petiolus 2–4 cm. longus; stipulæ petiolo supra medium adnatæ et cum eo quasi vaginam herbaceam formantes, parte libera herbacea lineari-oblonga obtusa vel subacuta 3–5 mm. longa uti petiolus facie et in dorso dense velutino-stellato-tomentosa, ad margines stellato-ciliata; lamina ambitu late ovata vel cordata, trifida, circa 1·2 cm. longa, 1·2 cm. lata, supra dense velutino-stellato-tomentosa, infra stellato-tomentosa, segmentis trilobis, lobis integris vel trisectis lobis et lobulis obovato-oblongis. *Flores* petiolo ad medium insidentes. *Calyx* ultra medium 5-lobus, 1·0–1·1 cm. longus, lobis triangulari-ovatis acutis 6–7 mm. longis, velutino-stellato-tomentosus. *Corolla* cæruleo-violacea, circa 2 cm. longa; petala spathulata, retusa, basi in tubum 3–4 mm. longum coalita. *Stamina* in cylindricam columnam instructa, filamentis liberis brevibus. *Carpella* 6 mm. longa, late birostrata, rostris 2 mm. longis, dorso stellato-pilosa.

Ecuador: Quito, *Jameson*, 154; Chimborazo, 4600 m., *Jameson* (Herb. Kew.); Chimborazo, Paramo Region, 4200–4500 m., *Hans Meyer*, 151 B (Mus. Berol.); Chimborazo, 4377 m., *Whymper* (Herb. Brit. Mus.); Antisana, W. side, 4600 m., *Whymper*, 17 (Herb. Kew.).

The specimens included under this new species have been formerly included under either *N. phyllanthos* or *N. pichinchensis*. It is distinguished from them particularly by the dense velvety tomentum which covers the whole plant and by the corolla-tube, in both of which characters it shows resemblance to *N. artemisioides*. The species appears to be confined to the mountains Chimborazo and Antisana.

22. Nototriche artemisioides, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. p. 580.

Peru: Dep. Cajamarca, in montibus prope Hualgayoc, 3900–4000 m., *Weberbauer*, 4068 (Herb. Berol.: Pl. 28. fig. 6).

In this species the stamens, which are relatively few, are arranged in a somewhat elongated head.

Both in this species (Pl. 28. fig. 6) and in *N. Lobbii* (Pl. 28. fig. 8) the lamina is deeply divided, so much so that it appears at first more natural to place these species amongst the forms with deeply dissected leaves. Yet as regards their leaf-structure they seem to show a definite affinity to *N. obtusa*.

In all three species the whole plant is covered by a soft velvety tomentum. *N. obtusa*, *N. artemisioides*, and *N. Lobbii* thus appear to be three nearly related forms. Moreover, an affinity appears to exist between these forms through *N. artemisioides* with *N. Jamesonii* and the other species from Ecuador.

23. Nototriche Lobbii, A. W. Hill (desc. emend.).—*Fruticulus* ramosus, subherbaceus, sæpius pulvinatus; caudex tenuis, lignosus, ramosus. *Folia* aggregata, cinereo-viridia; petiolus 2·5–3 cm. longus; stipulæ petiolo supra medium adnatæ (in foliis non-floriferis sæpius abortæ) et cum eo quasi vaginam circa 2 mm. latam formantes, parte libera lineari-acuta vel filiformis circa 5 mm. longa uti petiolus et vagina facie

et in dorso dense stellato-velutino-tomentosa; lamina flabellata, ambitu semicircularis vel reniformis, profunde trifida vel etiam palmatifida, circa 1·0 cm. longa, 1·5 cm. lata, utrinque dense stellato-velutino-tomentosa, segmentis 2–3-lobis, lobis 2–3-lobulatis, lobulis ultimis 2–3 mm. longis lineari-spathulatis obtusis sæpissime inflexis. *Flores* petiolo ad medium insidentes. *Calyx* ad medium 5-lobus, circa 1·2 cm. longus, extra minute stellato-tomentosus, lobis lineari-oblongis obtusis intus tomentosis. *Corolla* in sicco aurantiaca, 1·5–1·8 cm. longa; petala obovato-unguiculata, truncata, apice concava, paullo laciniata, basi in tubum circa 2 mm. longum coalita. *Stamina* in cylindricam columnam instructa, filamentis liberis brevibus. *Carpella* 10, matura non visa.

Malvastrum Lobbii, Baker fil. in Journ. Bot. xxix. 1891, p. 365.

COLOMBIA ?, without precise locality, *Lobb* (Herb. Kew.: Pl. 28. fig. 8).

This is an interesting specimen, which has been named *Malvastrum Lobbii* by Baker, bearing the label "Colombia, Lobb," in the writing of Sir W. Hooker. It is unfortunate that we have no definite information about the locality of this plant, which is very distinct owing to its caulescent habit and apparently orange corolla. The cylindrical arrangement of the stamens occurs, but there is also a short corolla-tube. For a figure of the leaf, *v.* Pl. 28. fig. 8.

Some difficulty exists both as to the collector of this species and also of the Kew specimen of *N. Meyeni*, E. Ulbrich (p. 239). Both are attributed to W. Lobb, who apparently only travelled in the Chilian Andes and the island of Chiloe *. *N. Meyeni* is, however, a native of S. Bolivia and Peru, and it appears probable that *N. Lobbii* comes from still more northern regions. The name of Lobb may therefore have been added to these specimens in error. No specimens of *Nototriche* are known from Colombia as now defined, but it is possible that the home of *N. Lobbii* is in Northern Peru or in Ecuador. There is also a specimen of *N. pedicularifolia* at Kew with the label "Andes, S. Chile, W. Lobb," but the habitat of this species is very similar to that of *N. Meyeni*.

24. NOTOTRICHE LANATA, A. W. Hill.—*Fruticulus* depressus, cæspitosus, pulvinatus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* aggregata, plus minusve laxe rosulata, lano-cinerea; petiolus 1·5–2 mm. longus; stipulæ petiolo supra medium adnatæ et cum eo quasi vaginam membranaceam (luteam) 2–3 mm. latam formantes, parte libera membranacea subulata 5–7 mm. longa uti petiolus facie glabra vel sparse stellata in dorso et ad margines plus minusve dense lanato-stellato-tomentosa; lamina ambitu plus minusve rotundata, circa 1·2 cm. longa et lata, flabellatim 5- vel 7-9-fida, supra sparse stellato-tomentosa, infra dense lanato-stellato-tomentosa, segmentis majoribus ambitu cuneatis vel ovato-cuneatis pinnatifidis, lobis et segmentis minoribus lateralibus integris vel 3-lobulatis vel incisis lacinulis brevibus congestis lineari-obtusis. *Flores* ad petiolum medium insidentes. *Calyx* ad medium 5-lobus, circa 9 mm. longus, lanato-stellato-tomentosus, lobis triangulari-acutis intus tomentosis. *Corolla* roseo-violacea, circa 1·8 cm. longa; petala late obovato-cuneata,

* *Vide* 'Hortus Veitchii,' pp. 37–40.

retusa, basi in tubum 5 mm. longum coalita. *Carpella* circa 8, fere matura, 6 mm. longa, rostris late subulatis 2 mm. longis, dorso breviter stellato-pilosa.

Bolivia: Dep. La Paz, nerr Copacabana, felsite mountains, 4400 m., *A. W. Hill*, 83; Dep. La Paz, near Huaycho, N.E. side of Lake Titicaca, stony hill-sides, *A. W. Hill*, 84 (Herb. Kew.: Pl. 29. fig. 18).

This species somewhat resembles *N. flabellata* collected by Mandon. It differs, however, in having the lamina much more deeply cut than is usual in that species (Pl. 29. fig. 18), in the tomentum of more silvery and shaggy stellate hairs, in the smaller calyx, and in the colour and form of the corolla. It is perhaps more nearly allied to the group containing *N. pedicularifolia* (*q. v.*, p. 246). This plant was found on the dry stony hill-sides of the Copacabana peninsula on the S.W. side of Lake Titicaca and in a similar position on the N.E. side of the lake near Huaycho. As there is no record of this species from the main chains of either the Eastern or Western Cordillera, it seems possible that it may be confined to this small area, and may have spread from the Copacabana peninsula to the N.E. side of the lake across the narrow straits of Tiquina or *vice versâ*.

25. Nototriche Macleanii, A. W. Hill (desc. emend.).—*Fruticulus* depressus, cæspitosus, pulvinatus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* arcte aggregata, imbricata, incano-viridia; petiolus 1·5–2 cm. longus; stipulæ petiolo supra medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera lineari-spathulata membranacea 5–6 mm. longa, supra ad apicem lano-stellato-tomentosa, infra uti vagina (supra et infra) plus minusve glabra; lamina flabelliformis, palmatisecta, 5–6 mm. longa, 1·0–1·2 cm. lata, supra lanato-stellato-tomentosa, infra subglabra, segmentis profunde trilobatis (segmento medio raro 5-lobato), lobis obovatis crenatis. *Flores* fere in petiolum medium insidentes, sessiles. *Calyx* ultra medium 5-lobus, 1·5 cm. longus, lobis lineari-lanceolatis acutis circa 9 mm. longis, extus sparse stellato-pilosus. *Corolla* cæruleo-violacea, 3–3·5 cm. longa; petala obcuneata, retusa, basi in tubum vix coalita. *Stamina* in columnam cylindricam instructa, filamentis liberis elongatis. *Carpella* matura non visa, ut videtur breviter birostrata, dorso dense stellato-tomentosa.

Malvastrum Macleanii, A. Gray, in Bot. U.S. Explor. Exp. p. 152 in adnot; Wedd. Chlor. And. ii. p. 280; Baker fil. in Journ. Bot. xxix. p. 364.

Peru: High Cordillera, *Maclean* (Herb. Kew.: Pl. 29. fig. 13); Arapa near Yauli, above Hacienda, Lima-Oroya Railway, 4600 m., *Weberbauer*, 382; above Oroya, 4300 m., *Weberbauer*, 1705 (Herb. Berol.).

The corolla-tube is practically absent in this species and the stamens are arranged in a cylindrical head with fairly long free portions to the filaments.

This species is not in any way nearly allied to *N. pedicularifolia* (*v.* Weddell, Chl. And. ii. p. 280), but appears to show affinity to *N. aretioides*, though it is conspicuous and distinct with its large flowers. A figure of the leaf is given on Pl. 29. fig. 13.

26. Nototriche aretioides, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. p. 580.

Malvastrum aretioides, A. Gray, in Bot. U.S. Explor. Exp. p. 153; Wedd. Chlor. And. ii. p. 279; Baker fil. in Journ. Bot. xxix. p. 364.

Peru: Dep. Lima, reg. Alp. des Cord. à Casa Cancha, *Pickering* (Herb. Gray); Dep. Lima, Hacienda Arapa prope Yauli, ad Lima-Oroya viam ferream, 4400 m., *Weberbauer*, 289 (Herb. Berol.: Pl. 29. figs. 15, 16).

This species, originally collected on the U.S. Exploring Expedition, is of interest in having stiff stellate spines on the back of the vagina (Pl. 29. figs. 15, 16), which probably serve some protective function. This appears to be the only species in which some of the normal stellate hairs have been replaced or supplemented by stellate spines.

27. Nototriche pichinchensis, A. W. Hill.—*Fruticulus* depressus, cæspitosus, 6–8 cm. diametro sæpius pulvinatus; caudex subterraneus, lignosus, firmus, crassus, ramosus, surculis horizontalibus instructus. *Folia* laxe rosulata vel plus minusve aggregata, incano-viridia; petiolus 2–4 cm. longus; stipulæ petiolo supra medium adnatæ et cum eo quasi vaginam membranaceam 4–5 mm. latam formantes, parte libera late triangulari- vel lineari-subulata 8–10 mm. longa supra et infra glabra vel sparsissime stellata ad margines stellato-ciliata; lamina ambitu flabelliformis vel rotundato-reniformis, profunde tripartita, circa 1·8 cm. longa, 2·2 cm. lata, supra dense incano-stellato-velutina, coriacea, infra vernicosa, glabra vel sparse stellata, segmentis 3–5-fidis, lobis ovato-oblongis obtusis 5–8 mm. longis marginibus inflexis integris vel raro 1–2-lobulatis parvis lateralibus. *Flores* fere ad petiolum medium adnatæ, breviter pedicellatæ. *Calyx* ad medium 5-lobus, circa 1·6 cm. longus, lobis triangalari-ovatis vel lanceolatis acutis plus minusve dense lanato-stellato-tomentosus. *Corolla* in sicco pulchre violacea, speciosa, circa 3 cm. longa; petala obovato-spathulata, retusa, 8–15 mm. lata, basi in tubum vix coalita. *Stamina* in cylindricam columnam instructa. *Carpella* circa 12, matura non visa.

Sida pichinchensis, Humb. et Bonpl. Pl. Æquin. ii. p. 115, tab. 116; H. B. et K. Nov. Gen. v. p. 264; DC. Prod. i. p. 466.

Malvastrum pichinchense, A. Gray, in Bot. U.S. Explor. Exp. p. 152; Wedd. Chlor. And. ii. p. 278; Baker fil. in Journ. Bot. xxix. p. 362.

Ecuador: Quito, *Jameson*, 282; without precise locality, *Manderville*, *Lobb*, *J. Hennecart*; près Quito, *Boussingault*, 1832; in summa Pichincha, *Bonpland*, 3032 (tab. 116) (Herb. Mus. Paris.); *Jameson* (ann. 1859) (Herb. Kew.; Pl. 29. fig. 12; Pl. 30. fig. 9), *Jameson*, 282 (Herb. Brit. Mus.; Herb. Univ. Cantab.); Antisana, *Whymper* (Herb. Brit. Mus.).

Nototriche pichinchensis, var. angusta, A. W. Hill.—*Petiolus* sub 1 cm. longus; stipulæ parte libera 7 mm. longa; lamina ambitu cordato-reniformis, profunde tripartita vel 5-fida, 1 cm. longa, 1·6 cm. lata, segmentis profunde trifidis vel trilobis, lobis denuo trilobatis, lacinulis (circa 27) lineari-oblongis obtusis marginibus paullo

inflexis 4–6 mm. longis, infra sparsissime stellata. *Calyx* 1–1·3 cm. longus, fere ad medium 5-lobus. *Corolla* circa 2 cm. longus. *Carpella* immatura.

Malvastrum pichinchense (forma), Hieron. in Engl. Bot. Jahrb. xx. Beibl. n. 49, p. 43.

ECUADOR: Andes Quitensis, *Spruce*, 6542 (Herb. Kew.; Herb. Univ. Cantab.); Chimborazo, 4000 m., 4971; Pichincha, *Sodiro*, 159 (Herb. Berol.).

The plants labelled "*S. pichinchensis*, 14,000 ft." and Hartweg's plant No. 917 in Herb. Kew. differ from the specimens collected under *N. phyllanthos* in a few points: the leaf-lamina is about 1–1·2 cm. long by 1·5 cm. across, with three segments trilobed and each again trilobate, also the vagina and petiole are stellately hairy above. These plants seem to afford a link connecting plants like Spruce, no. 6542, with those which can be definitely referred to *N. phyllanthos*, and are probably very close to the above-described variety of *N. pichinchensis*.

Under the name *Malveopsis pichinchensis*, O. Kuntze, var. *decolorans*, O. Kuntze, in Rev. Gen. Plant. iii. 2, p. 21, Kuntze describes a plant:—"Flores albi striato-cærulescentes. Bolivia: 5000 m., Tunarigebirge."

From our knowledge of the habitat of *N. pichinchensis* it seems unlikely that Kuntze's plant belongs to this species.

For further notes on this species see p. 260. A figure of the leaf is given (Pl. 29. fig. 12).

28. NOTOTRICHE PHYLLANTHOS, A. W. Hill.—*Fruticulus* depressus, cæspitosus, circa 3 cm. diametro, pulvinatus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* arcte aggregata, incano-viridia; petiolus circa 8 mm. longus; stipulæ petiolo prope ad laminam adnatæ et cum eo quasi vaginam membranaceam 3·5–4 mm. latam formantes, parte libera triangulari-subacuta plus minusve glabra 3–4 mm. longa ad margines stellato-ciliata; lamina rotundato-reniformis, tripartita, 8–10 mm. longa, 1·0–1·3 cm. lata, segmentis 3–5-fidis vel lobis, lacinulis integris ovato-oblongis obtusis rarius lobulatis, supra velutina, infra vernicosa, glabra, vel sparsissime stellata. *Flores* fere ad petiolum medium adnatæ. *Calyx* ad medium 5-lobus, circa 1 cm. longus, pilis stellatis obtectis. *Corolla* circa 1·8–2·0 cm. longa, violacea; petala basi in tubum vix coalita. *Stamina* in cylindricam columnam instructa. *Carpella* circa 9 mm. longa, birostrata, dorso stellato-ciliata, rostris 4 mm. longis.

Sida phyllanthos, Cav. Diss. 276, t. 127. fig. 4.
Sida phyllanthos, H. B. et K. Nov. Gen. v. p. 264.
Sida saxifraga, Humb. et Bonpl. Pl. Æq. ii. p. 116, in adnot.
Malvastrum phyllanthos, Wedd. Chl. And. ii. p. 278 (partim).
M. pichinchense, A. Gray, in Bot. U.S. Expl. Exp. p. 152; Wedd. Chl. And. ii. p. 278 (partim).

ECUADOR: Antisana, *Bonpland*, 2257 (ex herb. Humb. Herb. Berol.); Antisana, *Jameson*, 32 (Herb. Kew.; Herb. Univ. Cantab.); Antisana et Pichincha, *Hartweg*, 917 (Herb. Kew.; Mus. Paris.; et Herb. Lemann in Herb. Univ. Cantab.); Paramos del Cerro Antisana, Cerro de la media luna, 4400 m., *Stübel*, 168 D (Herb. Berol.); Cotopaxi, 4200 m., *Meyer*, 150 (Herb. Berol.); Antisana, 4790–5000 m., S. side

4300–4600 m., *Whymper* (Herb. Mus. Brit.); Antisana, 4600–4900 m., *Whymper* (Herb. Mus. Brit.); without precise locality, 4300 m., *Pearce* (Herb. Kew.).

NOTOTRICHE PHYLLANTHOS forma.—*Folia* petiolis circa 1·7 cm. longis, stipulis petiolis mediis adnatis partibus liberis 4 mm. longis late subulatis uti petiolis facie et in dorso et ad margines dense stellato-tomentosis, laminis profunde trifidis 8–10 mm. longis, 10–12 mm. latis, segmentis trifidis lobis obovatis marginibus inflexis supra densissime stellato-velutino-tomentosis infra coriaceis stellato-tomentosis. *Calyx* circa 9 mm. longus. *Corolla* 1·6–1·7 cm. longa. *Carpella* 7·5 mm. longa, birostrata, stellato-tomentosa, rostris 2·5 mm. longis.

COLOMBIA: (? ECUADOR) without precise locality, *Hartweg*, 917 (Herb. Lindley in Herb. Univ. Cantab.).

The Nototriches of Ecuador (*N. pichinchensis*, *N. phyllanthos*, *N. Jamesonii*, and *N. Hartwegii*) offer considerable difficulties to the systematist, and although all the literature has been studied and the material from Paris, Berlin, Kew, the British Museum, and Cambridge has been examined, there are still certain outstanding questions. Cavanilles* in the first instance described two species of *Sida* from the kingdom of Quito—*S. pinnata*, *S. acaulis*, and also *S. phyllanthos*† from Peru. He was then followed by Humboldt‡, who described two additional species—*S. pichinchensis* and *S. saxifraga*. Subsequently § this last species was merged with the *S. phyllanthos* of Cavanilles, although Cavanilles's plant is said to come from Peru, whilst the locality of *S. saxifraga* is Antisana in Ecuador. As Cavanilles's type has not been seen, and as it has proved impossible to obtain information from Madrid, it is not possible to settle this point conclusively, but the two descriptions certainly suggest that these two specimens belong to one and the same species. To add to the confusion, Hartweg brought back two species bearing the numbers 917 and 918: the former was referred to *Sida pichinchensis*, H. & B., whilst no. 918 was referred to *Sida phyllanthos*; and in this determination Bentham || was followed by Weddell ¶, who quotes these two numbers in the 'Chloris Andina.' The *Sida pinnata* and *S. acaulis* of Cavanilles have been identified by Asa Gray ** with two specimens brought by Pickering from the Cordillera above Lima, and are redescribed by him under the names *Malvastrum pinnatum* and *M. Cavanillesii* respectively; but in view of the fact that Cavanilles's plants came from Quito it seems highly probable that these determinations are not correct.

From a careful study of the material available under the specific names of *phyllanthos* and *pichinchensis*, it is evident that we have here a very closely-related series of forms in which certain well-marked types can be distinguished, but which tend to be united together by forms more or less intermediate in character. When this region is better

* Cav. Icon. v. p. 13, t. 422. figs. 1, 2.

† Cav. Diss. v. pp. 276, 277, t. 127. fig. 4.

‡ Humb. Pl. Æquin. pp. 115–117, t. 116.

§ Humb., Bonpl., & Kunth, Nov. Gen. et Spec. v. p. 264.

|| Benth. Pl. Hartwegianæ, p. 164.

¶ Weddell, Chlor. And. ii. p. 278.

** Gray, in Bot. U.S. Expl. Exp. pp. 154, 156.

known and more intelligently explored it will no doubt be possible to get a clearer idea of the relationships of the various forms to one another.

At present the ripe fruits are known from only a few plants, and without doubt they form a very important basis for classification. Four species are defined in this paper.

(1) *N. pichinchensis.*—The well-marked large form, with conspicuous mauve flowers about 3 cm. in length, of which we have no ripe fruits. It is of this plant that Jameson says in a note at Kew:—"*S. pichinchensis* occurs only between the elevation of 15,000–16,000 feet. It forms a sort of dense turf, and, from the beauty of the flowers, enlivened in no small degree the gloomy aspect of the surrounding scenery,—the *Chuchiraga insignis* is the only shrub reaching the same level. We likewise met with several Compositæ, such as *Culcitium* and *Espeletia grandiflora*." It occurs on Pichincha and on Chimborazo * more sparingly (Jameson, 1859, ann.). A well-marked varietal form of the true *N. pichinchensis*, growing mainly or entirely on Chimborazo, differs from the true form in having the smaller leaf-lamina much more dissected, with the lobes longer and narrower and the corolla only about 2 cm. in length. These forms are probably identical with the form mentioned by Hieronymus † from Chimborazo.

(2) *N. phyllanthos.*—Closely allied to the true *N. pichinchensis* are the forms which I believe to be the *Sida phyllanthos*, Cav. ‡, and *S. saxifraga*, H. & B. §. They are represented in the herbaria by no. 2257, Bonpland, from Antisana (Herb. Mus. Paris. and Herb. Berol.), and by some specimens of Hartweg, 917 ‖, and of Whymper from Antisana and Pichincha. Their distinguishing characteristics are that the petioles and laminæ are hairy on both sides, more or less densely, and the stipules are adnate only to the middle of the petioles, which are about 1·5 cm. long. The lamina is trifid, each segment being trilobed with obovate-obtuse lobes, entire or again more or less 3-lobed: and in these points the plants accord very well with the descriptions of Cavanilles. It is from Hartweg, 917, that the only ripe fruits of this group of forms are known.

Another form very closely allied to the preceding may very possibly be only a varietal form. It is, however, much more like a dwarf form of *N. pichinchensis*. The leaves are glabrous and varnished on the under surface and the stipules are adnate almost to the lamina. The lamina, which is really trifid, tends to become palmatifid by the development of the two external lobes, and the median lobe tends to be 5-lobed as in *N. pichinchensis*. The type-specimen of this form is Jameson's no. 32, in which the leaves are closely packed in small rosettes only about 3 cm. in diameter. This specimen is labelled *Sida phyllanthos* both at Kew and at Cambridge and comes from Antisana. With it agree the forms labelled Hartweg, 917, at Kew, a Cambridge specimen from the herbarium of Dr. Lemann, named by Bentham, and also a plant at the British Museum collected by Whymper on Antisana ¶.

* According to Whymper, 'Travels among the Great Andes of Ecuador,' p. 199, *M. pichinchensis* was found on Antisana at an elevation of from 15,000–16,000 feet.

† Hieron. in Engl. Bot. Jahrb. xx. Beibl. no. 49, p. 43.

‡ Cav. Diss. v. 276, t. 127. f. 4.

§ Humb. et Bonpl. Pl. Æq. ii. p. 116 adnot.

‖ Hartweg, 917, Colombia, in Herb. Dr. Lindley in Herb. Univ. Cantab., Herb. Kew., and Herb. Mus. Brit.

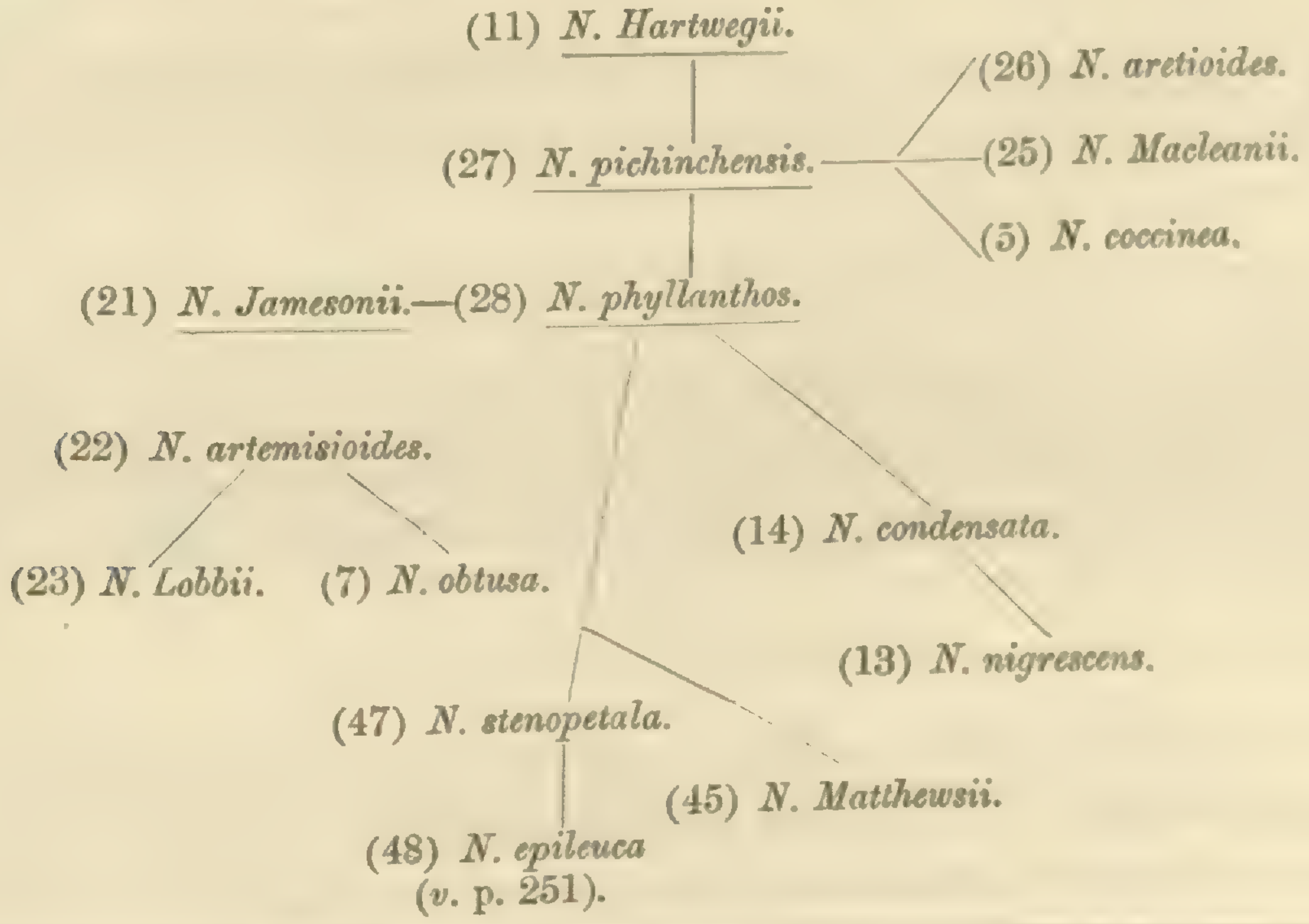
¶ *v.* Whymper, *l. c.* p. 199.

(3) *N. Jamesonii.*—From the hairy forms (the true *N. phyllanthos*) one passes to another type, which I have named *N. Jamesonii*, a very distinct plant in certain particulars, but very possibly linked with *N. phyllanthos* by intermediate forms. The types of this species are two specimens of Jameson's at Kew (no. 154) and the specimen labelled "Chimborazo, 15,000 ft. (Aug. 1829)." A specimen from Chimborazo (14,359 feet) at the British Museum, collected by Whymper *, and Meyer's no. 151 B, from the Paramos of Chimborazo at 4200–4500 m. alt., are also identical with the Kew species. The chief distinguishing characters of this species are the long petioles, which, like the laminæ, are covered with a velvety pubescence on both sides; the velvety calyx; and the corolla, which is larger than that of *N. phyllanthos*, and differs markedly from that of the two preceding species in the possession of a corolla-tube 3–4 mm. in length. The stamens, however, are arranged in a cylindrical head and the carpels have shorter beaks. It is also of interest to note that Chimborazo appears to be the home of this species, and it may be that it is due to its isolation on this mountain that this particular specific type is being developed.

(4) *N. Hartwegii.*—To the forms already mentioned must be added Hartweg's no. 918, which was determined by Bentham to be *Sida phyllanthos*, Cav., a determination which was accepted by Weddell. Much of the confusion connected with these northern forms is due to this erroneous identification. This plant, with which a specimen at Kew collected by Jameson also agrees, is very distinct from all the others, and very easily distinguished as a definite and well-marked new species, which I have named *N. Hartwegii.* The habit of growth, nature of the tomentum, and the shape and lobation of the lamina, &c., mark it off clearly from *N. phyllanthos*, which is perhaps its nearest ally.

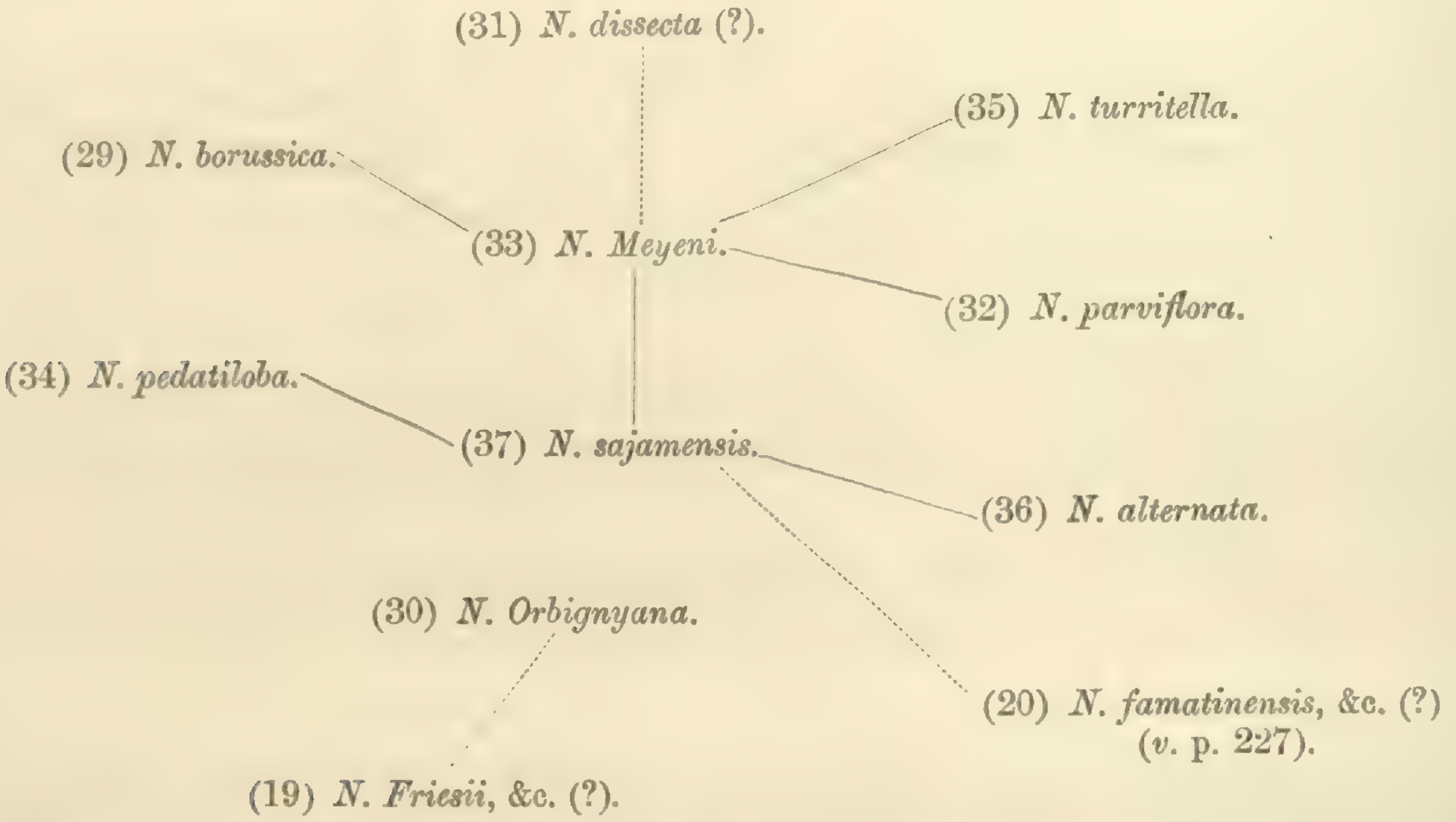
It is possible that a definite affinity exists between these northern species and *N. Macleanii* (Pl. 29. fig. 13), *N. Matthewsii* (fig. 11), *N. stenopetala* (fig. 17), and *N. epileuca.*

In the following diagram an attempt is made to represent the possible alliances of the four species under discussion :—



* Whymper, *l. c.* p. 334.

The species which now follow appear to be a group of closely related forms, with the possible exception of *N. dissecta*. They all agree, however, in the deeply cut lamina, which is divided into a large number of segments. Their relationships to one another may be represented, to some extent, in a graphic manner, but a fuller discussion will be found in the notes on the several species.



29. Nototriche borussica, A. W. Hill.—*Fruticulus* depressus, cæspitosus; caudex subterraneus, lignosus. *Folia* rosulata, in hemisphæricum congesta, argenteo-albo-tomentosa; petiolus 1 cm. longus; stipulæ petiolo infra medium—ad 2 mm.—adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera subulata 3 mm. longa, vagina facie glabra in dorso—uti petiolus facie et in dorso—minute stellato-tomentosa; lamina reniformis, flabellatim profunde 5–7-fida, circa 3–4 mm. longa, 7 mm. lata, segmentis 3–5-lobis, lobis cuneatis utrinque molliter incano-stellato-tomentosa. *Flores* infra petiolum medium insidentes. *Calyx* ad medium 5-lobus, 9 mm. longus, lobis triangulari-ovatis obtusis, utrinque molliter incano-stellato-velutinus. *Corolla* alba et nigro-violacea, circa 1·5 cm. longa. *Carpella* matura non visa.

Sida borussica, Meyen, Reise um die Erde, ii. 31; Wlprs. in Nov. Act. Acad. Cæs. Leop.-Carol. Nat. Cur. xix. suppl. i. p. 308.
Sida rosula, Meyen, MS. quoted in Wedd. Chl. And. ii. p. 278.
Malvastrum borussicum, Wedd. Chl. And. ii. p. 278.

Peru: "sur le haut plateau, au voisinage du lac de Titicaca," 3800 m., *Meyen* (4/31) (Herb. Berol.).

Chili: Prov. Tacna, Tacora, 4670 m., *Meyen* (Herb. Kew.).

Both at Kew and Berlin there are two distinct forms on the sheets bearing the name *S. borussica*, Meyen. The species from the region of Lake Titicaca collected by Meyen is the true *N. borussica*, and is easily recognised by its long free petioles, soft white tomentum, and cuneate leaf-lobes. The other species has been named *Malvastrum*

Meyenii by Count Solms * and is allied to *N. Orbignyana*. The Berlin specimen is from Kunth's Herbarium and was collected, according to the label, from the "altos de Toledo," Peru, at 15,000 ft., whilst the Kew specimen, which exactly agrees with this plant, bears the label "Lobb, S. Chile," in the handwriting of Sir W. Hooker. In this latter case there is no doubt some mistake, and the habitat of *N. Meyeni* extends, probably, from the country on the borderland of Chili, Peru, and Bolivia, as far as the shore of Lake Titicaca: owing to the fragmentary nature of the material, it has not been possible to make a complete diagnosis of this species. A resemblance to *N. parviflora* may be noticed in the form and cutting of the lamina and in the shape of the lobes, and *N. borussica* is very possibly allied to that species. It is, however, very distinct, particularly in its universal white tomentum.

According to Weddell †, this species is only a variety of *M. phyllanthos*, but the statement must have been made from superficial observation.

Meyen in his description of this plant ‡ states that the leaves are covered with silver-white hairs. The plants form small isolated rosettes growing amongst the black ash and the flowers are striped white and dark violet or almost black; he goes on to say, in reference to the colour of the flowers, "wesshalb diese Blümchen, in dem sie die Preussische National-Farbe zeigten, einen um so grösseren Reiz für uns hatten, und wir auch der Art den Namen *Sida borussica* gegeben haben."

This species was found by Meyen on the volcanic ash near the 'alto de los Huesos,' a more or less flat tract of country lying at an elevation of about 13,300 feet on the borders of the departments of Arequipa and Puno at the foot of the southern slopes of the cone of the volcano El Misti. This volcanic ash, in which several species of *Nototriche* flourish, has been derived from the volcano which rises directly from the plateau.

30. Nototriche Orbignyana, A. W. Hill.—*Fruticulus* depressus, cæspitosus, pulvinatus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* dense congesta, cinerea; petiolus 1·2–1·5 cm. longus; stipulæ petiolo ad medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera membranaceo-herbacea filiformi 1·0–1·2 cm. longa uti vagina facie in dorso et ad margines sparse stellato tomentosa; lamina ambitu flabellata, inæqualiter trifida, circa 6–8 mm. longa, 1·2–1·4 cm. lata, supra lanato-stellato-tomentosa, infra sparse tomentosa, segmentis lateralibus 4-fidis, laciniis integris vel 2–3-lobis, segmento medio 3–5-lobo, lacinulis linearibus vel obovato-linearibus obtusis 2–4 mm. longis. *Flores* ad petiolum medium insidentes. *Calyx* ultra medium 5-lobus, circa 8 mm. longus, lobis circa 5 mm. longis triangulari-acutis extus lanato-stellato-tomentosis intus glabris, tubo extus sparse stellato-tomentoso. *Corolla* 1·0–1·2 cm. longa, purpurea (intense cærulea); petala late obovata, retusa, basi in tubum sub 2 mm. longum coalita. *Stamina* in caput

* Solms-Laubach, in Bot. Zeit. 1907, p. 126.
† Wedd. Chl. And. ii. p. 279 in obs.
‡ Meyen, 'Reise um die Erde,' vol. ii. p. 31.

globosum instructa. *Carpella* fere matura circa 2·5 mm. longa, birostrata, rostris circa 1 mm. longis, dorso sericeo-pilosa.

Malvastrum Orbignyanum, Wedd. Chlor. And. ii. p. 279; Baker fil. in Journ. Bot. xxix. p. 364 (partim).
Malvastrum Copelandii, Hieron. in Engl. Bot. Jahrb. xx. Beibl. no. 49, p. 43.

Bolivia: Potosi, "lagunas ad niveum in quebrada," *D'Orbigny*, 1351 (Herb. Mus. Paris.); Prov. Larecaja, prope Sorata, 4500 m., Mandon, 800 (Herb. Mus. Paris., Herb. Kew., &c.).

Peru: Vincocaya, 4376 m., *Copeland* (Herb. Berol.).

There is a note by Weddell on Mandon, 800, in Paris Herbarium, "= var. hirsutior quoad petiolos et calycem." The three collections attributed to this species show certain individual differences, but they do not seem to be of sufficient importance to merit description.

As in *N. sajamensis*, the stipules are filiform and the cutting of the lamina is somewhat similar. In *N. Orbignyana*, however, the cutting is much deeper and the segments are long. The corolla-tube is very short and the stamens are arranged in a globular head. In *N. sajamensis* there is a corolla-tube 5 mm. in length.

31. Nototriche dissecta, A. W. Hill.—*Fruticulus* depressus, cæspitosus, pulvinatus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* arcte aggregata, sulphureo-viridia; petiolus circa 1 cm. longus; stipulæ petiolo supra medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera herbacea lineari-acuta 8–9 mm. longa uti petiolus lanato-stellato-tomentosa; lamina ambitu semicircularis, profunde trifida, circa 6 mm. longa, 1·2 cm. lata, supra dense infra laxe lanato-stellato-tomentosa, segmentis æqualibus biternatifidis, 27-lobis, lobis lineari-oblongis subacutis. *Flores* breviter pedicellati, ad petiolum medium insidentes. *Calyx* fere ad medium 5-lobus, lanato-stellato-tomentosus, 8–9 mm. longus, lobis anguste triangularibus acutis. *Corolla* rosea, circa 1·7 cm. longa; petala oblongo-obovata, subtruncata, basi in tubum 6 mm. longum coalita. *Carpella* matura non visa.

Malvastrum Orbignyanum, Baker fil. in Journ. Bot. xxix. p. 364, partim, non Wedd.

Peru: Dep. Apurimac, Andahuaylas, 3900–4300 m. (Feb. 1867), *Pearce* (Herb. Kew et Mus. Brit.: Pl. 28. fig. 13).

This very beautiful species collected by R. Pearce, has until now been confused with *N. Orbignyana*, to which it bears some external resemblance; the leaf-cutting, however, is very regular and the three main segments are all of equal size (Pl. 28. fig. 13), whilst in *N. Orbignyana* the median segment is the smallest. The tomentum of stellate hairs with long stiff bristles gives this species a characteristic appearance. The large rose corolla with its long tube also distinguishes this species easily from *N. Orbignyana*. The leaf-rosettes form regular hemispherical little cushions about 4 cm. in diameter, which are more or less yellow in colour, owing to the dense felt of hairs covering the leaves.

32. Nototriche parviflora, A. W. Hill.—*Fruticulus* depressus, cæspitosus, minimus, pulvinatus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* dense congesta, imbricata, incano-viridia; petiolus circa 6 mm. longus; stipulæ petiolo supra

medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera membranacea lineari-obtusa 3 mm. longa uti vagina facie et in dorso glabra, ad margines sparse stellata; lamina ambitu plus minusve reniformis, 2 mm. longa, 5 mm. lata, trifida, segmentis lateralibus vulgo 3-fidis vel flabellatim 7-lobis, lobis integris vel trifidis, lacinulis obcuneatis vel oblongo-obtusis supra et ad apicem supra et infra sparse stellato-tomentosis. *Flores* leviter petiolo insidentes. *Calyx* supra medium 5-lobus, 5–6 mm. longus, lobis triangulari-acutis circa 2 mm. longis sparse stellatis. *Corolla* rosea, 3–3·5 mm. longa, obovata, basi in tubum sub 1 mm. longum coalita. *Carpella* circa 8, 3–3·5 mm. longa, bi-rostrata, rostris 1 mm. longis, dorso minute stellata.

Malvastrum parviflorum, Philippi, Viaje à la Prov. de Tarapacá, p. 9; Baker fil. in Journ. Bot. xxix. p. 363; Reiche, Fl. Chile, i. p. 235.

CHILI: Prov. Tarapacá, Alto de Machuca, 3200 m., *Philippi* (Herb. Kew.: Pl. 28. fig. 10).

This species is easily distinguished from its nearest allies by its minute flowers, and, like the other forms collected by Philippi in the desert of Atacama, may represent a dwarf reduced form of some species growing in the Puna of Bolivia a little further to the north. With the exception of the two annuals, *N. parviflora* is the smallest known species of this genus. It appears to be most closely allied to *N. Meyeni* and *N. turritella.*

From the figure of the leaf it will be seen that the lamina appears to be cut into three segments, the median one remaining small, whilst the two lateral ones are broken up into two or three 3-lobed portions (Pl. 28. fig. 10). A similar type of lamina is found in *N. Meyeni* (Pl. 28. fig. 9).

A figure of the fruit is given (Pl. 30. fig. 11).

33. NOTOTRICHE MEYENI, E. Ulbrich, in Engl. Bot. Jahrb. xlii. 1908, p. 120.

Malvastrum borussicum, Wedd. Chlor. And. ii. p. 278, partim.

Malvastrum sajamense, Hieron. in Engl. Bot. Jahrb. xxi. p. 319, partim.

Malvastrum Meyeni, Solms-Laubach, nomen in Bot. Zeit. 1907, p. 126.

PERU, CHILI, BOLIVIA: in mont. Sajama vel Tacora, 4500–4800 m., *Stübel*, 108 i. A (Herb. Berol.).

PERU: Altos de Toledo, 4700 m., *Meyen* (ex herb. Kunth in Herb. Berol.); without precise locality, *Lobb* (Herb. Kew.: Pl. 28. fig. 9).

This plant, to which the name *Meyeni* has been given by Count Solms-Laubach, was collected in the first instance by Meyen in 1831, and has recently been described by E. Ulbrich. Specimens occur both at Berlin and at Kew and in each case they are on the same sheet with a very different form, the true *Sida borussica* of Meyen (*v.* note on *N. borussica*, pp. 236, 237). The only other specimens of this species are among Stübel's collection from Sajama and Tacora and were formerly included under *Malvastrum sajamense.* The habitat of the species therefore seems to be in the Puna of the borderland region of Chili, Bolivia ,and Peru.

Count Solms has dealt at some length * with the question of the relationship of this

* Solms-Laubach, in Bot. Zeit. 1907, pp. 126, 127.

species to *Nototriche Orbignyana* and *N. sajamensis*, and it seems clear that *N. Meyeni* occupies a more or less intermediate position, as regards its leaf-form, between these two species. Between *N. Meyeni* and Philippi's *N. parviflora* there is a close similarity not only in the lobation of the lamina, but also in the broad membranous stipules (Pl. **28.** figs. 9, 10), a character which is also seen in my own species *N. pedatiloba* and *N. turritella*; the relationship to this latter species is also pointed out by Ulbrich *.

The uniformly minute size of the various parts of *N. parviflora*, however, prevents the possibility of confusion between these two species. Both in *N. Orbignyana*, with which I have united *M. Copelandii*, Hieron. (v. p. 238), and in *N. sajamensis* the stipules are filiform and so serve to distinguish these two species from *N. Meyeni*.

It is unfortunate that ripe fruits have not been found on these specimens; those collected by Meyen have beaked carpels which are ciliate (Pl. **30.** fig. 12). In Stübel's plants only a few carpels appear to come to maturity and the beaks were not clearly seen.

34. NOTOTRICHE PEDATILOBA, A. W. Hill.—*Fruticulus* depressus, cæspitosus, pulvillus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* arcte aggregata, plus minusve imbricata, incano-viridia; petiolus circa 8 mm. longus; stipulæ petiolo usque ad laminam adnatæ et cum eo quasi vaginam membranaceam circa 6 mm. latam formantes, parte libera membranacea circa 2 mm. longa 3 mm. lata truncata uti vagina facie et in dorso glabra ad margines minute stellato-fimbriata; lamina ambitu semicircularis vel reniformis, flabellatim circa 11-fida, 3 mm. longa, 7 mm. lata, supra incano-stellato-pubescens, infra glabella, segmentis profunde 4–5-lobis, lobulis circa 50 carnosulis lineari-obovatis obtusis 1·5 mm. longis. *Flores* prope basim petiolo insidentes, breviter pedunculati. *Calyx* campanulatus, plus minusve inflatus, rubro-purpureus, 1·0 cm. longus, supra medium 5-lobus, lobis triangulari-obtusis pubescentibus 3 mm. longis, tubo glabro. *Corolla* violacea, 1·6–1·8 cm. longa; petala obovata, cuneata, retusa, basi in tubum 5 mm. longum coalita. *Carpella* 6–8, 5–6 mm. longa, birostrata, stellato-tomentosa, rostris circa 2 mm. longis stellato-ciliatis.

PERU: Dep. Arequipa, Vincocaya, 4376 m., *A. W. Hill*, 78 (Herb. Kew.: Pl. **27.** fig. 4; Pl. **28.** fig. 12; Pl. **30.** figs. 5, 10, 20).

This species (Pl. 27. fig. 4) was found in the form of small cushions carpeting the ground together with *N. argyllioides* at Vincocaya near the summit of the Arequipa-Puno railway. The deeply and multi-lobed leaves (Pl. **28.** fig. 12) point to a relationship between this species and *N. sajamensis* and *N. Meyeni*. The leaf-lamina is divided up into erect fleshy lobulæ, covered with stellate hairs on their upper surfaces. The lobulæ, which occur in little groups of four or five, are really the lobes of the leaf divided almost to their bases. Each leaf is thus made up of about fifty lobulæ borne on a small pedate expansion (Pl. **28.** fig. 12). The plant is easily distinguished from all others by the broadly truncate, membranous stipules. The ruddy colour of the calyx with its pubescent lobes and its inflated condition as the carpels ripen are also characteristic features of this species (Pl. **30.** fig. 5). For the fruits, *v.* Pl. **30.** figs. 10, 20.

* Ulbrich, in Engl. Bot. Jahrb. xlii. 1908, p. 121.

35. NOTOTRICHE TURRITELLA, A. W. Hill.—*Fruticulus* depressus, cæspitosus, turritellanus, 2–5 cm. supra humum altus; caudex subterraneus, lignosus, firmus, crassus, ramosus, foliis confertissimis vetustis protectis. *Folia* conferta, imbricata, cinerea, foliis floriferis et vegetativis verticillatim dispositis; petiolus 4–6 mm. longus; stipulæ petiolo fere ad laminam adnatæ et cum eo quasi vaginam membranaceam circa 3 mm. latam formantes, parte libera lineari-oblonga obtusa circa 3 mm. longa 2 mm. lata uti vagina facie glabra in dorso et ad margines dense stellato-tomentosa; lamina ambitu late cuneata vel cuneato-reniformis, obscure trifida, 4–5 mm. longa, circa 8 mm. lata, supra et infra dense stellato-pubescens, segmento medio parvo, sed 9–11-fida, segmentis lateralibus iterum 3–5-lobis, lobis plurilobulatis, lobulis spathulatis facie superiori interne spectantibus quasi in sarcinas arcte aggregatis, apicibus carnosulis glabris. *Flores* imam petioli basin insidentes, sessiles. *Calyx* tubuloso-campanulatus, 9 mm. longus, supra medium 5-lobus, utrinque dense stellato-pubescens, lobis 3·5 mm. longis triangulari-oblongis obtusis, apicibus carnosulis glabris. *Corolla* pallide violacea, medio purpurea, 1·3–1·5 cm. longa, plus minusve rotata; petala late obovata vix retusa, basi in tubum circa 5 mm. longum coalita. *Carpella* circa 8, abortu sæpissime 1 maturantia, 4 mm. longa, minute birostrata, rostris sub 1 mm., dorso stellato-pilosa. *Semina* dorso sulcata.

PERU: Dep. Arequipa, Volcano El Misti, 4000–5000 m., *A. W. Hill*, 81 (Herb. Kew.: Pl. 27. figs. 1, 2; Pl. 28. figs. 11, 16; Pl. 30. figs. 6, 13; text-fig., p. 202); Vulcan El Misti, Alto de los Huesos, 3700 m., *Weberbauer*, 1421 (Herb. Mus. Berol.).

This species appears to be confined to the slopes of the volcano El Misti above Arequipa: it was found both by Weberbauer and myself and I was able to traverse its whole vertical range of about 1000 metres. The ultimate branches of the plant, covered by their dense felt of leaves, stand out of the black volcanic ash like little turrets to a height of from two to five centimetres (text-fig., p. 202, and Pl. 27. figs. 1, 2). The flowers are borne at the apices of the leaf-rosettes and are in striking contrast to their surroundings. In shape they resemble small Crocus-flowers and with their pale violet colour and deep purple centres form conspicuous and beautiful objects, when in full flower about the middle of March. The leaf-lamina is trifid in structure, with a small median segment (Pl. 28. figs. 11, 16), but appears to be 7–11-lobed on account of the deep cutting of the two lateral lobes. The young leaves are densely hairy all over, but when older the tips of the lacinulæ are glabrous and resemble finger-tips sticking out of the fingers of a minute woolly glove (Pl. 28. figs. 11, 16). The lacinulæ are arranged in little packets of 4 or 5, with their upper surfaces turned inwards and closely wefted together by their hairs. Of the eight carpels usually seen in each flower (Pl. 30. fig. 13), only one as a rule comes to maturity and affords a suggestive link with the apparently monœcious species *N. Azorella* and *N. congesta* (*v.* pp. 219, 220).

A figure of the corolla of this species is given (Pl. 30. fig. 6) to show a typical case of a well-developed fusion of corolla and staminal column to form the corolla-tube.

36. NOTOTRICHE ALTERNATA, A. W. Hill.—*Fruticulus* depressus, cæspitosus, pulvinatus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* arcte aggregata, congesta,

imbricata, et florifera et non florifera verticillatim disposita; petiolus 8–10 mm. longus; stipulæ petiolo circa ad medium adnatæ, parte libera herbacea lineari-subacuta 4–5 mm. longa uti vagina facie plus minusve glabra in dorso minute sparse stellato-tomentosa; lamina cum petiolo supra stipulas dilatato ambitu late cuneata, flabellatim circa 7-fida, 6–7 mm. lata, supra dense infra sparse minute stellato-tomentosa, segmentis 1·5–2·5 mm. longis plus minusve integris vel 3–5-fidis, lobis lineari-obtusis carnosulis apice glabris luteis inflexis. *Flores* fere basi petioli insidentes, ei circa 2 mm. adnati. *Calyx* supra medium 5-lobus, circa 1 cm. longus, lobis triangulari-ovoideis subacutis circa 4 mm. longis minute stellato-tomentosis, tubo plus minusve glabro. *Corolla* 1·5–1·6 cm. longa; petala obovata ad 5 mm. lata, basi in tubum 5 mm. longum coalita. *Carpella* matura lignosa, 8 mm. longa, birostrata, rostris 3 mm. longis, dorso stellato-hirsuta. *Semina* 3–4 mm. longa, dorso sulcata.

Malvastrum sajamense, Hieron. in Engl. Bot. Jahrb. xxi. p. 319, partim.

PERU, CHILI: Tacora, 4200 m., *Stübel*, 108 ii. (Herb. Berol.).

Stübel collected several specimens *, now in the Berlin Herbarium, under the numbers 5 and 108, either on the mountains of Sajama in Bolivia or Tacora on the boundaries of Chili and Peru. They are in five separate packets on the Herbarium sheets, which I have distinguished as no. 5 i. ii. and iii., and no. 108 i. and ii. All these specimens were referred by Hieronymus to his new species *M. sajamense*, but a careful examination of the material showed that at least four different species were included in the different packets. *N. sajamensis* is the most frequent and packets 5 i., ii. in part, iii., and 108 i. in part, are occupied by this species. The packet 108 ii. contains the new species *N. alternata*, so named from the regular alternations of whorls of vegetative and flower-bearing leaves on the stems; packet 5 i. in part contained specimens of *N. obcuneata*, whilst packet 108 i. in part (part A) contains specimens which are apparently identical with the species named *M. Meyeni* by Count Solms †. Though Stübel's material appears to have been carelessly collected, it is nevertheless of interest to learn from it that these four distinct species all grow in close contiguity.

The plants of *N. alternata* show a certain external similarity to *N. sajamensis*, *N. Meyeni*, and *N. turritella*. In the latter species there is also a similarly whorled arrangement of the leaves: those which bear the flowers only occur apparently at regular —perhaps annual—intervals, and are separated from each other by a whorl of sterile leaves.

In *N. alternata* the distinction between petiole and lamina is not easy to determine; the petiole is dilated to form a broad flattened cuneate expansion bearing the short lobes of the lamina at its apex. The large woody carpels found in this species are also remarkable: they are twice as large as those of *N. turritella* and also differ from them in their longer beaks. It is unfortunate that ripe fruits of neither *N. sajamensis* nor *N. Meyeni* have been collected.

* Hieronymus, G., "Plantæ Stübelianæ novæ," in Engl. Bot. Jahrb. xxi. (1896) p. 318.

† Solms-Laubach, in Bot. Zeit. 1907, p. 126.

37. NOTOTRICHE SAJAMENSIS, A. W. Hill.—*Fruticulus* depressus, cæspitosus, pulvinatus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* apice ramorum rosulata, plus minusve imbricata; petiolus 6–8 mm. longus; stipulæ supra petiolum medium adnatæ et cum eo quasi vaginam membranaceam 4 mm. latam formantes, parte libera herbacea lineari- vel fili-formi obtusiuscula circa 5 mm. longa 1 mm. lata uti vagina facie et in dorso glabra ad margines stellato-ciliata; lamina ambitu reniformis, flabellatim 9–11-fida, circa 4–5 mm. longa, 1·0–1·2 cm. lata, supra plus minusve dense infra sparse stellato-tomentosa vel infra subglabra, segmentis profunde trifidis laciniis profunde bi- vel trifidis, lacinulis obovato- vel lineari-oblongis obtusis 1·5–2 mm. longis. *Flores* imæ basi petioli insidentes, breviter pedunculati. *Calyx* supra medium 5-lobus, 8–9 mm. longus, lobis triangulari-ovatis obtusiusculis circa 3 mm. longis stellato-hirsutis, tubo subglabrato. *Corolla* lutescenti-albida *, in sicco nigro-purpurea, 1·0–1·4 mm. longa; petala ovata, acutiuscula, basi in tubum circa 5 mm. longum coalita. *Carpella* circa 8, matura non visa, birostrata, rostris 1·5 mm. longis, dorso stellato-ciliata.

Malvastrum sajamense, Hieron. in Engl. Bot. Jahrb. xxi. p. 319, partim.

BOLIVIA: Sajama, 4800 m., *Stübel*, 5 i. (Pl. 28. fig. 14), 5 ii. partim, 5 iii.; Sajama vel Tacora, 4500–4800 m., *Stübel*, 108 i. partim (Herb. Berol.).

CHILI: Volcano of Tacora, near Tacna, 4800–4900 m., *Steinmann*.

Solms-Laubach † gives an account with some figures of *N. sajamensis* (*cf.* Pl. 28. fig. 14). As already noted, it appears to be allied with *N. Orbignyana* on the one hand and *N. alternata* on the other.

The following species—the *Pedicularifolia* section—appear to be fairly closely allied and to form a natural group. The lamina is deeply divided into five distinct segments, which tend to be pinnately or bipinnately lobed with usually crenately-lobed and crisped lobulæ. The character of the leaf-lamina may be somewhat variable in a few species, especially in *N. rugosa* and in *N. argyllioides* (Pl. 27. figs. 6, 7); but in typical cases the median segment is much more strongly developed than the others, both as regards its length and the number of the lobes, so that a pinnatifid type of leaf tends to be developed from the palmatifid. *N. Philippii* shows the simplest type of leaf, in which each segment though pinnately lobed is equally developed. In the specimens of *N. argyllioides* collected by Weddell there is every gradation from an oblong inciso-crenate lamina (Pl. 27. fig. 6) to a regular deeply cut palmatifid type, and in my own specimens of this species the development of the leaf has proceeded still further, becoming pinnatifid (Pl. 27. fig. 7), until it is closely similar to that of *N. pedicularifolia* (Pl. 27. fig. 5).

The most striking of the forms included in this subsection is *N. sulphurea*, whose leaves are covered by a dense, yellow, woolly tomentum (Pl. 29. figs. 3, 4). It is somewhat uncertain whether the forms which have been grouped together owing to the similarity of their leaf-form may or may not represent a real alliance; the form of the corolla in *N. pedicularifolia*, *N. Lorentzii*, and *N. sulphurea*, where the tube is practically

* Hieron. in Engl. Bot. Jahrb. xxi. (1896) p. 319.

† Solms-Laubach, in Bot. Zeit. 1907, pp. 122, 125, and figs. 1, 3, and 14.

absent and the stamens are arranged in a cylindrical head, probably indicates that these three species are more closely allied to each other than to the other species included in this group.

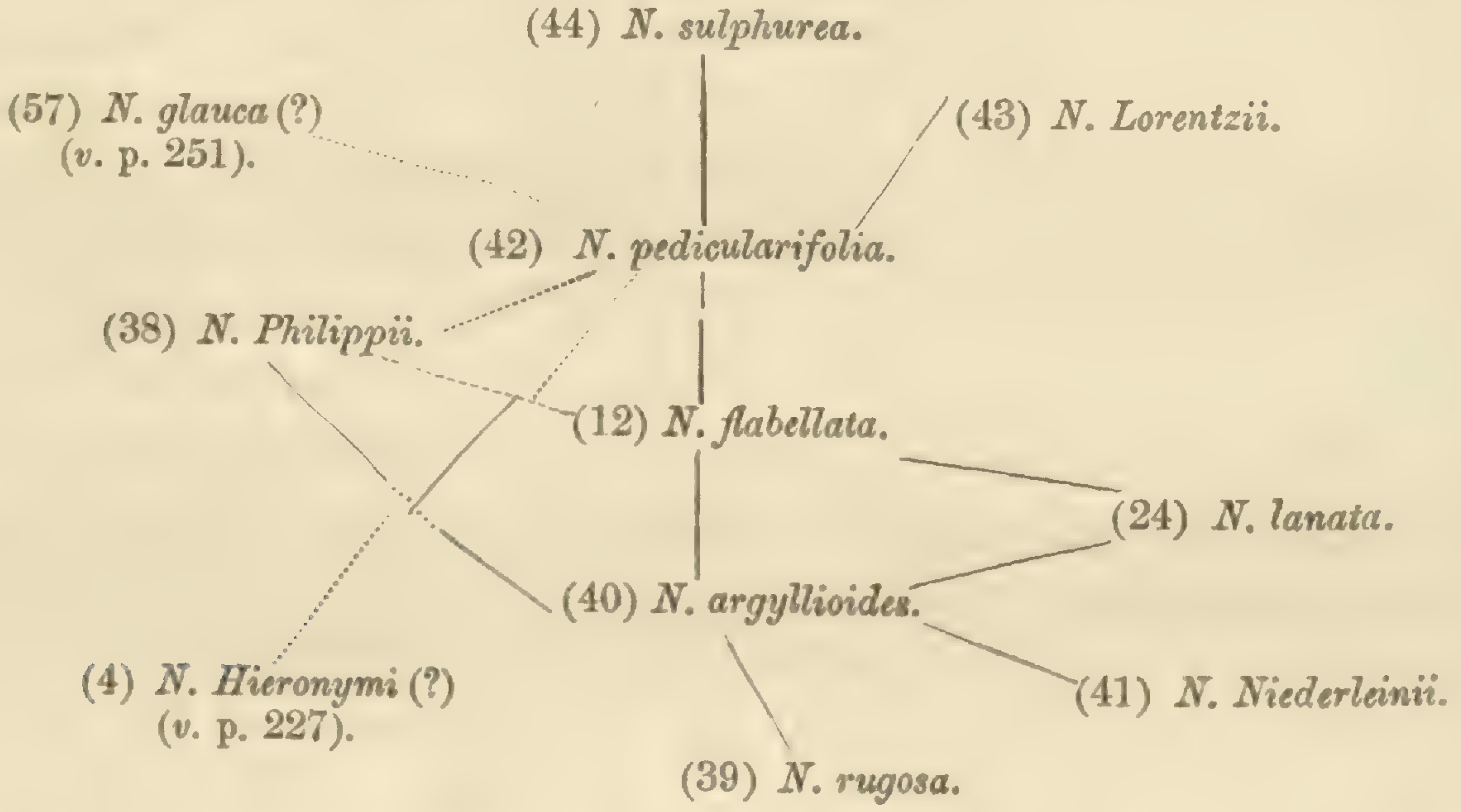
The apparent absence of a beak to the carpels in *N. pedicularifolia* (Pl. 30. fig. 16) and *N. Lorentzii* also distinguishes these two species from all others.

From the geographical point of view they form a fairly close group. *N. Philippii* and *N. rugosa* come from the northern part of the Atacama desert, Chili, whilst *N. Niederleinii* and *N. Lorentzii* are found to the east of this region, over the crest of the Andes in the Argentine Republic. *N. pedicularifolia* has been collected in the south of Bolivia, and extends north-westwards along the western Cordillera to Vincocaya in the Peruvian Dept. of Arequipa—the locality for *N. argyllioides,*—and is also recorded from Ananca *, in the province of Sandia, on the borders of Peru and Bolivia. It is curious that no localities are recorded for this species on the eastern range of the Cordillera between Potosi and Ananca. It is of interest to notice that *N. sulphurea,* whose leaf is the most distinct and peculiar, also comes from the province of Sandia, which region may perhaps be regarded as the northern limit for this subsection.

N. Hieronymi (Pl. 28. fig. 5) from the Argentine may be cited as a form possibly related to *N. Philippii*, whilst *N. lanata* (Pl. 29. fig. 18) shows some resemblance both to *N. argyllioides* and to *N. pedicularifolia.*

A form similar to *N. flabellata* (p. 222, Pl. 29. fig. 2) may very well be considered to have been the starting-point for such a group of forms as are here brought together. The corolla-tube is practically absent in *N. flabellata* (Pl. 30. fig. 8), in which point it resembles *N. pedicularifolia* and its nearest allies, and in the form of the lamina it shows resemblances to *N. lanata, N. argyllioides, N. rugosa*, and *N. Philippii.*

The relationships of the various species therefore appear to be somewhat as follows:—



With regard to *N. pedicularifolia*, it may be noticed that *N. sulphurea* appears to be the northern variant, while *N. Niederleinii* has been developed in the south. *N. cinerea,*

* *Weberbauer*, No. 1023, Ananca, Prov. Sandia, a fragment with a piece of *N. obcuneata*, both loose in a capsule bearing this number (Herb. Mus. Berol.).

which is possibly allied to *N. pedicularifolia*, may be considered as an intermediate form between this group and the pinnate types.

38. NOTOTRICHE PHILIPPII, A. W. Hill.—*Fruticulus* depressus, cæspitosus, pulvinatus; caudex subterraneus, lignosus, firmus. *Folia* rosulata, arcte aggregata; petiolus 8–10 mm. longus; stipulæ petiolo paullo supra medium adnatæ et cum eo quasi vaginam 3 mm. latam formantes, parte libera 3–5 mm. longa acuta uti vagina facie et in dorso glabra apice paullo stellata; lamina ambitu pentagona vel rotundato-cordata, palmatim 5-fida, circa 6 mm. longa, 8 mm. lata, supra et infra incano-puberulento-stellato-tomentosa, segmentis palmatifidis, lobis obovatis obtusis integris vel lobulatis confertis. *Flores* ad petiolum medium insidentes. *Calyx* circa 9 mm. longus, ad medium 5-lobus, lobis triangulari-ovatis subacutis extus minute puberulento-stellato-tomentosis. *Corolla* in sicco cærulea, 1·0–1·2 cm. longa; petala obovata, obtusa, basi in tubum 2 mm. longum coalita. *Carpella* circa 14, matura non visa.

Malvastrum pedicularifolium, Baker fil. in Journ. Bot. xxix. p. 363, partim; Reiche, Fl. Chile, i. p. 234, non A. Gray.

CHILI: Prov. Tarapacá, desertum Atacama, 3200 m., *Philippi* (Feb. 1888) (Herb. Kew.).

39. NOTOTRICHE RUGOSA, A. W. Hill.—*Fruticulus* depressus, cæspitosus, sæpius pulvinatus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* plus minusve rosulata, aggregata, cinereo-pulverulenta; petiolus ad 2–5 cm. longus; stipulæ petiolo circa ad medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera membranacea subulata ad 5 mm. longa uti petiolus facie et in dorso glabra ad margines ciliata; lamina palmatim 5-secta vel digitatim lobata, circa 1 cm. longa, 1 cm. lata, supra dense pulverulento-stellato-pubescens, infra medio glabra, versus margines dense pulverulento-pubescens, lobis pinnatisectis inciso-crenatis crispis. *Flores* circa ad petiolum medium insidentes. *Calyx* fere ad medium 5-lobus, 6–7 mm. longus, tubo glabro, lobis ovato-obtusis 2–2·5 mm. longis pulverulento-pubescentibus. *Corolla* alba vel cærulea, 7–8 mm. longa; petala obovata, basi in tubum 3 mm. longum coalita. *Stamina* pauca, in caput globosum instructa. *Carpella* matura non visa.

Malvastrum rugosum, Phil. in Herb. Kew. ined.; Baker fil. in Journ. Bot. xxix. p. 364; Phil. Viaje à la Prov. de Tarapacá, p. 9. no. 35.

Malvastrum pedicularifolium, var. *rugosum*, Phil.; Reiche, Fl. Chile, i. p. 235.

CHILI: Prov. Tarapacá, Machuca, *Philippi* (Herb. Kew.; Herb. Berol.).

40. NOTOTRICHE ARGYLLIOIDES, A. W. Hill.—*Fruticulus* depressus, cæspitosus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* rosulata, incano-pulverulenta; petiolus 2–4 cm. longus, purpureus; stipulæ petiolo supra medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera membranacea lineari-lanceolata acuta ad 1 cm. longa uti petiolus facie et in dorso glabra ad margines glabra vel

sparsissime stellata; lamina ambitu varians, pentagona vel plus minusve ovata, palmati-loba vel palmati-fida, sæpius ei generis *Argylliæ* similis, 1·0–1·8 cm. longa, 8–12 mm. lata, supra incano-pulverulento-stellato-tomentosa infra sub medium glabra, lacinulis apicibus pulverulento-tomentosis, segmentis multilobis vel plus minusve bipinnatifidis inciso-crenatis sæpius crispis, segmento medio maximo. *Flores* inter stipulas supra petiolum medium insidentes. *Calyx* supra medium 5-lobus, 6–9 mm. longus, rubro-purpureus, lobis triangulari-acutis 2–3 mm. longis extra incano-pulverulento-tomentosis venis nigro-purpureis conspicuis, intra tomentosis, tuboque glabro. *Corolla* roseo-violacea vel roseo-alba, 1·8–2·0 cm. longa; petala late obovata, basi in tubum 5 mm. longum coalita. *Carpella* circa 10, circa 7·5 mm. longa, birostrata, rostris 2 mm. longis, dorso stellato-ciliata.

Malvastrum ulophyllum, Wedd. Chl. And. ii. p. 280, partim; Baker fil. in Journ. Bot. xxix. p. 364, partim.

Malvastrum ulophyllum, Hieron. in Engl. Bot. Jahrb. xx. Beibl. no. 49, p. 43, non Gray.

PERU: Dep. Arequipa, Cord. inter Puno et Arequipa, 4000 m., *Weddell*, 4394 (Herb. Mus. Paris.: Pl. **27.** fig. 6; Pl. **30.** fig. 18); prope Vincocaya, 4500–4600 m., *Copeland*; Vincocaya, 4376 m., *A. W. Hill*, 80 (Herb. Kew.: Pl. **27.** fig. 7; Pl. **30.** fig. 27).

In the type of its leaf this species is very closely allied to *N. rugosa*, and they also agree together in the general character and distribution of the tomentum, both on the lamina, stipules, and calyx (Pl. **27.** figs. 6, 7).

It is mainly in the deeper cutting of the lamina into five distinct segments and in the much larger flowers that *N. argyllioides* can be distinguished. Both these species show a reddish-purple colour on the petioles and calyces, which is a distinctive feature and is not seen in *N. Philippii* or other allied species.

The range of this species appears to be restricted, as specimens have been collected up to the present only in the immediate neighbourhood of Vinocaya, near the railway-line between Arequipa and Puno.

N. argyllioides is the species so long confused with *N. ulophylla* (*q. v.* p. 224), collected in the Cordillera near Lima by the U.S. Exploring Expedition.

The nearest ally to this species appears to be *N. Niederleinii* from the Argentine, in which the glabrous stipules and vagina and the pulverulent tomentum of the lamina are more or less identical in character. In the calyces and carpels (Pl. **30.** figs. 18, 27) and in the general shape of the lamina the chief distinguishing characters are to be found.

41. NOTOTRICHE NIEDERLEINII, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. p. 584.

ARGENTINA: Prov. de la Rioja, Sierra Famatina, Cuesta del Tocino, *Hieronymus et Niederlein*, 690 (Pl. **30.** fig. 15); Cueva del Perez, *Heironymus et Niederlein*, 371.

The lamina is glabrous below, and there is a corolla-tube of 4 mm. in length. In these respects there is considerable resemblance to *N. argyllioides* and *N. rugosa*. The carpel is shortly beaked and bears long bristle-like hairs (Pl. **30.** fig. 15).

42. NOTOTRICHE PEDICULARIFOLIA, A. W. Hill.—*Fruticulus* depressus, cæspitosus; caudex subterraneus, lignosus, firmus. *Folia* rosulata, solo adpressa, canescenti-tomentosa;

petiolus 2–3 cm. longus; stipulæ petiolo ad medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera lineari-acuminata circa 1 cm. longa facie plus minusve glabra in dorso et ad margines stellato-tomentosa, vagina et petiolus facie et in dorso stellato-tomentosa; lamina ambitu cordata vel pentagona, palmatifida, segmentis 5–7 subbipinnatifidis inciso-crenatis, 2 cm. longa, 1·5–2 cm. lata, supra et infra dense canescenti-tomentosa, novella dense incano-tomentosa, lacinulis crispis obtusis brevissimis rotundatis, pilis intertextis, segmento medio maximo bipinnatifido, segmentis lateralibus minoribus simplicioribus. *Flores* ad petiolum medium insidentes. *Calyx* fere ad medium 5-lobus, circa 8 mm. longus, undique canescenti-tomentosus, lobis triangulari-ovatis subacutis. *Corolla* violacea, circa 1·5 cm. longa; petala lineari- vel cuneato-oblonga, circa 3 mm. lata, apice retusa, basi in tubum vix coalita. *Stamina* in caput oblongum instructa. *Carpella* circa 12, rotundata, 2 mm. longa, dorso dense niveo-pilosa.

Sida pedicularifolia, Meyen, Reise um die Erde, i. p. 460; Walpers, in Nov. Act. Acad. Cæs. Leop.-Carol. Nat. Cur. xix. Suppl. i. p. 308.

Malvastrum pediculariæfolium, A. Gray, Bot. U.S. Expl. Exp. p. 152; Wedd. Chl. And. ii. p. 280; Baker fil. in Journ. Bot. xxix. p. 363; Hieron. in Eng. Bot. Jahrb. xx. Beibl. no. 49, p. 43.

Nototriche incana, Turcz. in Bull. Soc. Imp. Nat. Moscou, xxxvi. pt. 1, p. 567.

Peru: High plateau near Pisacoma, *Meyen*; Cord. de Tacora, *Weddell*; Tacora, 4570 m., *Meyen* (1836) (Herb. Kew.: Pl. 27. fig. 5); Vincocaya, 4500–4600 m., *Copeland*; Prov. Sandia, Ananca, 4700 m., *Weberbauer*, 1023 partim (Herb. Berol.).

Bolivia: Lagunas de Potosi, *D'Orbigny*, 1356 (Pl. 30. fig. 16); without number or precise locality, *D'Orbigny* (probably=no. 1353, type of *N. incana*, Turcz.) (Herb. Mus. Paris.); without precise locality (labelled S. Chile), *W. Lobb* (Herb. Kew.).

It has been already suggested * that *N. pedicularifolia*, A. W. Hill, is the *Nototriche incana*, Turcz., and as the evidence is so strongly in favour of this view, I have here definitely assumed that it is the case. This species is closely allied to *N. Lorentzii*, which is chiefly distinguished, however, by the presence of long hairs on the leaves. As regards the shape and arrangement of the leaves (Pl. 27. fig. 5), *N. pedicularifolia* agrees both with *N. argyllioides* and with *N. Niederleinii*, but the character of its corolla as well as the tomentum afford very ready means of separating it from the two latter species. The absence of a tube to the corolla in *N. pedicularifolia* and *N. Lorentzii* is a very characteristic feature, and may be one of considerable phylogenetic value; it is associated in these two species with long narrow petals, and suggests a probable alliance with *N. flabellata*, in which a similar type of corolla is found. An almost polypetalous corolla is also found in *N. sulphurea*; but this species, though doubtless nearly allied, can be readily separated from *N. pedicularifolia* by the character of its lamina, tomentum, and carpels.

The beakless carpels of *N. pedicularifolia* (Pl. 30. fig. 16), with their long silky hairs, serve to distinguish this species; unfortunately the ripe carpels of *N. Lorentzii* are not known, but the immature carpels resemble those of *N. pedicularifolia*.

* A. W. Hill, in Engl. Bot. Jahrb. xxxvii. p. 577.

43. Nototriche Lorentzii, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. p. 584.

Argentina: Prov. Salta, Nevado del Castillo, *Hieronymus et Lorentz*, 55.

The stellate hairs are large and crowded, and there are also long hairs in addition; the stipules are hairy at the margins; the lamina is not crisped to the same extent as in *N. pedicularifolia.* The corolla-tube is practically absent.

44. Nototriche sulphurea, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. p. 583.

Malvastrum pediculariæfolium, Baker fil. in Journ. Bot. xxix. p. 363, partim, non A. Gray.

Peru: Prov. Sandia, inter Poto et Ananca, 4700 m., *Weberbauer*, 963 (Herb. Berol.: Pl. **29.** figs. 3, 4); Andes of Pelechuco, *R. Pearce* (Herb. Kew.).

This species, which is the most northerly form of the *pedicularifolia*-group, is also the stoutest and the most robust, having a thick caudex of as much as 2·5 cm. in diameter; it shows considerable similarity to *N. pedicularifolia*, and has been sometimes included in herbaria under that species. The broader and longer petals, the beaked carpels, as well as the large leaves with their characteristic sulphurous tomentum afford a ready means of distinguishing this species (Pl. **29.** figs. 3, 4). The stamens are arranged in a more or less oblong head, as in *N. pedicularifolia*, the free portions of the filaments being very short; but there is a short corolla-tube of 1·5–2·5 mm. in length beset, like the base of the petals, with stellate hairs.

45. Nototriche Matthewsii, A. W. Hill.—*Fruticulus* depressus, cæspitosus, sæpius pulvinatus; caudex subterraneus, crassus, lignosus, firmus, ramosus. *Folia* aggregata, incano-viridia; petiolus circa 1 cm. longus; stipulæ petiolo supra medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera herbacea subulata 4 mm. longa, facie tomentosa, vagina facie plus minusve glabra, in dorso glabra, ad margines stellato-pilosa; lamina ambitu ovata, profunde palmatifida, raro trifida, aliquando pinnatifida, circa 1·5 cm. longa, supra lanato-sericeo-stellato-tomentosa, infra glabra, segmentis infimis parvis integris aliquando nullis, intermediis 7–8 mm. longis trifidis vel integris, segmento medio 3–5-lobo, lobis omnibus lineari-oblongis obtusis marginibus involutis. *Flores* ad petiolum medium insidentes. *Calyx* circa 1·1 cm. longus, ultra medium 5-lobus, lobis triangulari-acutis circa 7 mm. longis, ubique lanato-sericeo-stellato-tomentosus. *Corolla* in sicco cærulea 2–2·5 cm. longa; petala obovato-oblonga, unguiculata, retusa, basi hirsuta, in tubum vix coalita. *Stamina* in caput oblongum instructa, filamentis liberis brevissimis. *Carpella* 10, matura non visa, circa 4 mm. longa, birostrata, dorso stellato-tomentosa, rostris circa 2 mm. longis apice ciliatis.

Malvastrum pinnatum, Baker fil. in Journ. Bot. xxix. p. 365, partim; doubtfully of A. Gray, in Bot. U.S. Expl. Exp. p. 154; Wedd. Chl. And. ii. p. 281.

Peru: Cerro Pasco, *Matthews*, 682 (Herb. Kew., Pl. **29.** fig. 11; Herb. Univ. Cantab.) [? Reg. Alp. à Casa Cancha, *Pickering*. ?? Cord. de Cuzco, *Gay*].

The specimens, collected by Matthews, on which this species is founded, have been

referred to *Sida pinnata*, Cav., which was collected on Chimborazo, and is said * to have a yellow corolla. Other specimens referred to *S. pinnata*, Cav., were collected in Peru by the U.S. Exploring Expedition at Casa Cancha above Lima, and by Gay in the Cordillera of Cuzco †. It seems hardly likely that these two specimens can be the same as Cavanilles's plant; but as I have not been able to see, or obtain information about, these three plants, it is impossible to settle the question. It seems probable that the plants from Casa Cancha and from Cerro Pasco (Matthews) may belong to the same species, and that Gay's specimen may also have to be included. Owing to the uncertainty which prevails, Matthews's plant no. 682 has been taken as the type of a new species, *N. Matthewsii*, which I have separated entirely from the original *Sida pinnata*, Cav.

In the type of its lamina (Pl. 29. fig. 11) this species is of some interest. The lamina is cut nearly to the base into five segments, the two lowest of which are usually entire; the median segment, however, has elongated considerably and developed prominent entire lateral lobes, which, with the intermediate segments of the lamina, give the leaf a pinnate appearance. A comparison of the figure of the lamina with that of *N. pichinchensis* (Pl. 29. fig. 12) will show the way in which this type of lamina may have arisen. As regards the flower, the corolla-tube is practically absent, and the stamens are arranged in a cylindrical column.

46. Nototriche purpurascens, A. W. Hill.—*Fruticulus* depressus, cæspitosus; caudex subterraneus, lignosus, firmus, crassus—ad 1·5 diametro—ramosus. *Folia* rosulata, viridia; petiolus 1·5–4 cm. longus; stipulæ petiolo fere ad medium adnatæ et cum eo quasi vaginam membranaceam 3 mm. latam formantes, parte libera membranacea anguste triangulari-acuta 5 mm. longa, uti petiolus facie et in dorso glabra, lamina ambitu late ovata vel pentagona, palmatifida, circa 2 cm. longa, 2–2·5 cm. lata, supra dense stellato-tomentosa, infra glabra, segmentis infimis plus minusve integris 7–10 mm. longis, intermediis pinnatifidis, lacinulis 6–10, segmento medio pinnatifido, lobis majoribus et minoribus alternantibus, loborum omnium marginibus valde inflexis, lobis elongato-oblongis obtusis. *Flores* petiolo fere medio insidentes. *Calyx* campanulato-turbinatus, ad medium 5-lobus, lobis late ovato-triangularibus acutis, 1 cm. longus, extra glaber, purpurascens, venis purpureis, lobis intus tomentosis marginibus paullo reflexis. *Corolla* cuprea, 2–2·2 cm. longa; petala obovata, truncata vel retusa, unguiculata, basi in tubum 3–4 mm. longum coalita. *Stamina* in caput globosum instructa, antheris sessilibus. *Carpella* vix matura circa 4 mm. longa, breviter birostrata, dorso pilis 6 mm. longis dense ciliata.

Malvastrum Pearcei, Baker fil. in Journ. Bot. xxix. p. 364, partim.

Bolivia: prope La Paz, via ad Coroico, Lancha, 5000 m., *Mandon*, 796, 797 partim (Herb. Mus. Paris., Herb. Kew., &c.); Andes of Yungas, 4200–4600 m., *Pearce* (Herb. Kew.); Huayni Potosi, Franz Joseph Glacier, 4900–5200 m., *F. Germann*, 12 (Herb. Bot. Mus. Hamburg.).

Specimens belonging to this quite distinct species have been distributed with *Malvastrum Mandonianum*, under the number Mandon, 797, to all the European

* Cav. Icones, v. p. 13.

† Wedd. Chl. And. ii. p. 281.

Herbaria (*v.* Bull. Soc. Bot. France, xii. 1865, p. 82); it is also the plant, collected by Mandon under the number 796, which is labelled "*M. anthemidifolium*, A. Gray, var.," in the Herbaria of Paris and Kew, though at Paris it bears in addition a note by Weddell, "*Malvastrum verisimiliter*, spec. nov." Besides these two numbers, Pearce's specimen, placed by Baker fil. under *M. Pearcei*, also belongs to this species.

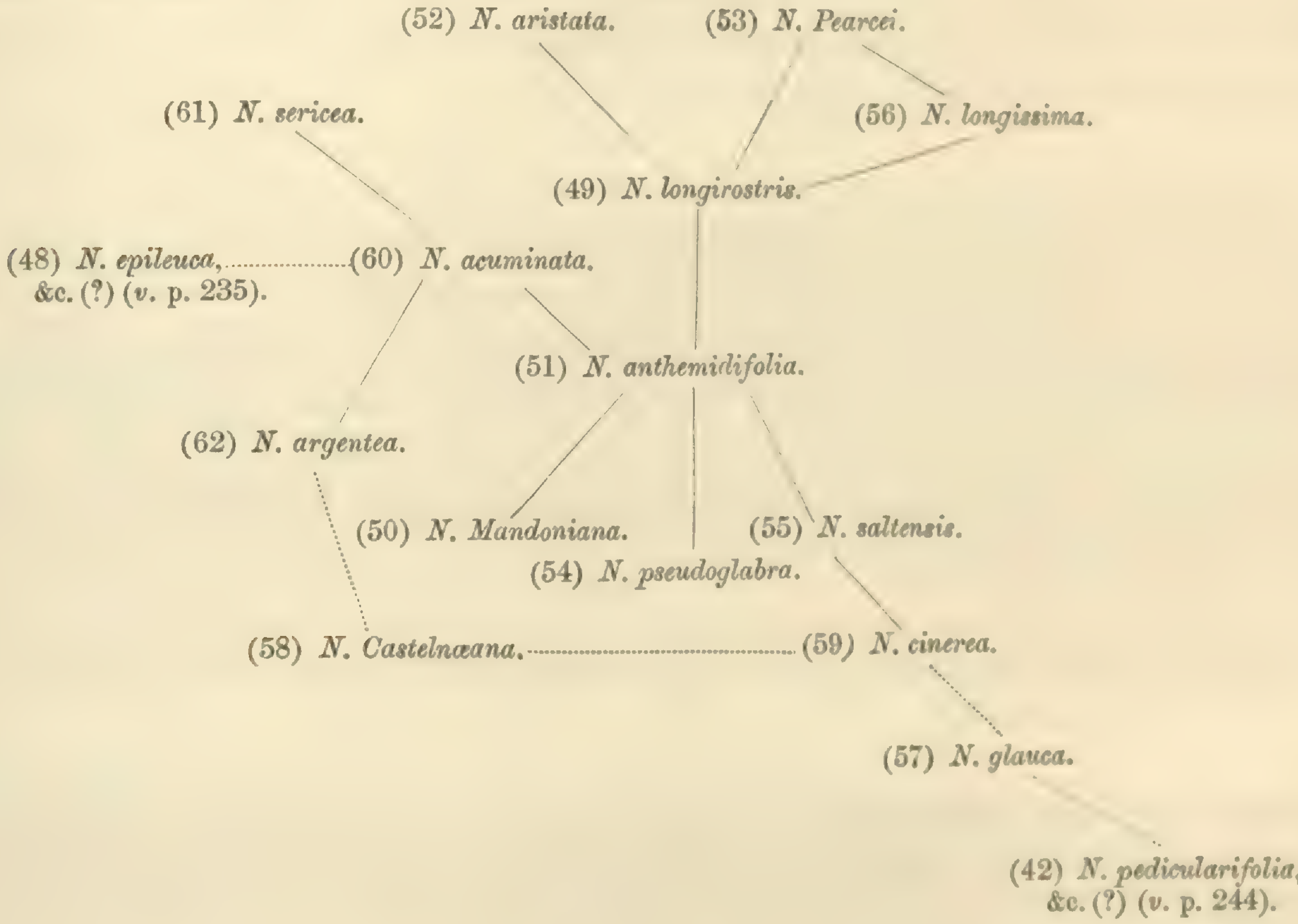
The anthers are few and dark purple, and are almost sessile on the staminal column, the free portions of the filaments being very short.

Some difficulty has been experienced in attempting to assign the two preceding species, *N. Matthewsii* and *N. purpurascens*, to their proper position in the genus.

In both species the lamina is deeply cut into five segments, and the segments have but few lobes; the lobes are long, linear-oblong in shape, with the margins slightly inrolled; the upper surface of the whole lamina is covered with a dense tomentum, while the lower is glabrous (Pl. 29. fig. 11). Though these species appear to belong to the palmatifid subsection, their nearest allies are to be found probably amongst the bipinnatifid forms, and it also seems certain that these two species are not really allied to one another. *N. Matthewsii*, with its almost polypetalous corolla, seems to be allied more closely to *N. stenopetala* than to any other species; in its leaf, too, it resembles that species in certain respects (*cf.* Pl. 29. fig. 17). *N. purpurascens* is also a very distinct and well-defined species, although it has been previously confused with *N. Mandoniana*, and has been distributed to Kew and other herbaria with this species under the number Mandon, 797.

The following group of species with bipinnatifid leaves appears to be in reality an offshoot from the forms having the palmatifid type of leaf, similar to the *pedicularifolia* section of the genus already described. The central lobe of the palmatifid leaf has in this case developed further and has produced lateral lobes, which have superseded in importance the original lateral lobes of the 5-lobed leaf, and the bipinnatifid character is thus given to the whole leaf. The various species can be easily separated into groups —as can be seen from the key—on account of the distribution and character of the tomentum. As a rule the species are hairy on the upper surface of the lamina only and the hairs form a more or less dense felt of definite stellate hairs. In some species, however, viz. *N. acuminata*, *N. sericea*, and *N. argentea*, both surfaces of the leaf have a tomentum of long hairs and a few species (e. g., *N. Castelnæana*, *N. cinerea*, and *N. glauca*) have a compact densely-stellate felt all over the lamina. Another point of considerable importance in this group is the character of the hairiness of the vagina. In some species, of which *N. anthemidifolia* may be taken as a type, the upper surface of the vagina is covered by a dense mass of long silky hairs (Pl. 30. fig. 1), while in other species, such as *N. aristata*, it is quite glabrous. Of the species included in the key under this subsection, *N. stenopetala* and *N. epileuca* do not appear to be very closely allied to the rest of the species. They differ particularly in their crimson, almost polypetalous corollas. *N. purpurascens* and *N. Matthewsii* also appear to occupy somewhat isolated positions, probably due to our imperfect knowledge of all the representatives of this genus.

The probable relationships of the various species of this group are roughly suggested in diagrammatic form :—



47. Nototriche stenopetala, A.W. Hill.—*Fruticulus* depressus, cæspitosus, pulvinatus ; caudex subterraneus, lignosus, firmus, ramosus. *Folia* aggregata ; petiolus circa 1·2 cm. longus ; stipulæ petiolo paullo infra medium adnatæ et cum eo quasi vaginam membranaceam 3 mm. latam formantes, parte libera membranacea subulata 3 mm. longa, uti petiolus, facie et in dorso glabra ; lamina ambitu triangularis vel cordata, trifida, lobo medio ampliore iterumque pinnatifidim diviso, circa 1·0 cm. longa, 1·2–1·3 cm. lata, supra dense niveo-velutino-stellato-tomentosa, infra glabra, segmentis trifidis vel integris, lobis 3–5 mm. longis lineari-oblongis marginibus paullo inflexis apice sæpius ciliatis. *Flores* infra petiolum medium insidentes. *Calyx* submedium 5-lobus, circa 9 mm. longus, lobis anguste triangulari-subacuminatis extra sparse stellatis intra dense niveo-tomentosis. *Corolla* punicea, circa 1·7 cm. longa ; petala anguste spathulata, basi in tubum haud coalita. *Stamina* pauca, in caput cylindricum disposita. *Carpella* circa 12, hirsuta, matura non visa.

Malvastrum stenopetalum, A. Gray, in Bot. U.S. Expl. Exp. p. 155 ; Weddell, Chl. And. ii. p. 282 ; Baker fil. in Journ. Bot. xxix. p. 365.

Peru : Andes of Peru, *Maclean* (Herb. Kew. : Pl. 29. fig. 17) ; Reg. Alp. des Cord. à Casa Cancha, *Pickering* (Herb. Gray).

The corolla is almost polypetalous and the stamens are arranged in a cylindrical head, showing a resemblance to *N. Matthewsii* and *N. epileuca* in this respect.

The leaf, with its somewhat varnished lower and hairy upper surface, resembles that

of *N. pichinchensis*; in form also it can be derived from the leaf of that species. The central lobe of the original 5-lobed leaf appears to have grown up carrying the pair of intermediate lobes with it (Pl. 29. fig. 17), with the result that a simple form of pinnate leaf has been produced. *N. Matthewsii* (Pl. 29. fig. 11) may perhaps be regarded as showing an intermediate stage in the process.

48. Nototriche epileuca, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. p. 585.

Peru: Dep. Ancachs, Prov. Cajatambo, Cordillera nigra inter Ocros et Chonta, 4400 m., *Weberbauer*, 2801 (Herb. Berol.: Pl. 30. fig: 28).

The corolla-tube is practically absent in this species and the stamens are arranged in an elongated head as in *N. stenopetala*. In the blood-red corolla colour and spathulate petals it also shows similarity to the latter species, but the leaf-form in the two species is very different; in *N. epileuca* there are numerous obtuse leaf-segments, whilst in *N. stenopetala* they are very few and acute.

49. Nototriche longirostris, A. W. Hill.—*Fruticulus* depressus, cæspitosus; caudex subterraneus, lignosus, firmus. *Folia* rosulatim disposita, viridia, indigofera, breviter petiolata; petiolus ad 2 cm. longus; stipulæ petiolo supra medium adnatæ et cum eo quasi vaginam membranaceam 4–5 mm. latam formantes, parte libera membranacea triangulari-acutiuscula ad 5 mm. longa, uti vagina facie plus minusve stellato-hirsuta in dorso plus minusve glabra ad margines setoso-ciliata; lamina ambitu lanceolata, bipinnati-partita, 1·0–1·5 cm. longa, supra plus minusve laxe stellato-tomentosa, infra glabriuscula, segmentis utrinque 3–4 sicut lobus terminalis 3–5-fidis, lacinulis oblongis vel linearibus obtusiusculis, apice sæpius piliferis. *Flores* infra petiolum medium insidentes. *Calyx* campanulatus, fere ad medium 5-lobus, 8–9 mm. longus, lobis triangulari-ovatis acutis plus minusve setoso-stellatis intus marginibusque setoso-tomentosis, tubo glabro. *Corolla* in sicco albo-violacea, 1·5–2·0 cm. longa; petala obovata, vix emarginata, basi in tubum 4 mm. longum coalita. *Stamina* in caput globosum instructa. *Carpella* 6–8, birostrata, circa 7 mm. longa, rostris circa 3 mm. longis, inferne stellato-tomentosa, superne breviter ciliata. *Semina* dorso sulcata.

Malvastrum longirostre, Wedd. Chl. And. ii. p. 281; Bull. Soc. Bot. Fr. xii. p. 82; Baker fil. in Journ. Bot. xxix. p. 365, partim; Solms-Laubach, in Bot. Zeit. 1907, p. 120, Taf. 2. figs. 5 & 12.

Peru: Andes of Cuzco, *F. de Castelnau*; without precise locality, *Cl. Gay*, 1478 (Herb. Mus. Paris.: Pl. 30. figs. 22, 23).

Bolivia: prope La Paz, via ad Coroico, 5000 m., *Mandon*, 795 (Herb. Paris.; Herb. Kew.); inter S. Pablo de Tiquina et Achacache, 4260 m., *A. W. Hill*, 75 (Herb. Kew.); Illimani, *Stübel*, 26 (Herb. Berol.); Cord. von Chuimsaruz, S. Illimani, 4000–5000 m., *Steinmann*.

This small species with bipinnatifid leaves shows a considerable amount of variation as to its degrees of hairiness, the adult leaves of my own specimens being almost

glabrous. By oversight the upper surface of the leaf is described by Weddell as glabrous and the lower tomentose, when the reverse is really the case. The type-specimen of this species, according to Weddell (Chl. And. ii. p. 281), is the Castelnau plant, but in the Paris Herbarium neither of the two plants on the sheet has fruits; on Gay's sheet (no. 1478), however, a loose capsule was tucked under the label bearing ripe fruits which appear to belong to Gay's plant. This latter specimen has been labelled *M. longirostre*, Wedd., by Weddell himself, and it was from it probably that he obtained the details of the fruits for his description, though the length of the beaks as given by Weddell is rather too long for these specimens. The occurrence of indigo in the leaves and calyces of the dried specimens of this species is clearly visible.

Mandon's specimens, no. 795, from La Paz, though not seen by Weddell, have been referred to *M. longirostre* (*v.* Bull. Soc. Bot. Fr. xii. p. 82); they differ somewhat in the character of their tomentum from the type-specimens and in the presence of cilia at the ends of the lobes of the leaf. Steinmann also collected a specimen of this plant on the slopes of Illimani, which I have been able to see through the kindness of Count Solms, and this plant has been figured by him in Bot. Zeit. 1907, Taf. 2. figs. 5 & 12. In his fig. 5 the corolla is incorrectly represented, as the tube has been broken off (*v.* Bot. Zeit. 1907, p. 138). The corolla in this species has a tube of about 4 mm. in length.

N. longirostris is the smallest of the pinnatifid species and is very rarely branched; the small plants consisting of a single leaf-rosette were found by me growing in the midst of low cushions of a species of *Azorella*. This species appears to be closely allied to *N. aristata*, a much more robust plant from the hills above Urubamba, in which the beaks of the carpels are about 4·5 mm. in length. The tomentum on the carpels in *N. longirostris* consists of short-armed stellate hairs on the body of the carpel and longer and more setose hairs on the beak (Pl. 30. figs. 22, 23). In *N. aristata* both the lower portion of the carpel and the beak are provided with stiff setose hairs (Pl. 30. figs. 25, 26).

50. NOTOTRICHE MANDONIANA, A. W. Hill.—*Fruticulus* depressus, cæspitosus; caudex subterraneus, lignosus, crassus. *Folia* rosulatim disposita, viridia; petiolus 2–2·5 cm. longus; stipulæ petiolo ad medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera membranacea lineari-lanceolata acuta circa 1 cm. longa, uti vagina et petiolus facie in dorso et ad margines setoso-stellato-ciliata; lamina ambitu obovato- vel elliptico-lanceolata, bipinnatifida, pinnatifida vel subpinnatifida, circa 1·5–2·5 cm. longa, supra stellato-tomentosa, infra glabra, sed in foliis immaturis aliquando sparse stellata, margine parce ciliata, lacinulis inæqualibus lineari-oblongis vel subacutis. *Flores* ad petiolum medium insidentes. *Calyx* circa ad medium 5-fidus, 8–10 mm. longus, lobis triangulari-ovatis acutis, extus subtiliter canescenti-velutino-stellato-tomentosus. *Corolla* roseo-violacea, 1·5–2 cm. longa; petala obovato-oblonga, retusa, basi in tubum 5 mm. longum coalita. *Carpella* circa 9, matura non visa.

Malvastrum Mandonianum, Wedd. in Chl. And. ii. p. 282; Bull. Soc. Bot. Fr. xii. p. 82, partim; Baker fil. in Journ. Bot. xxix. p. 364.

Bolivia: Apacheta de Chuchu (ann. 1856); Cord. de Sorata, *Mandon* (ann. 1857) (Herb. Mus. Paris.); prope La Paz, via ad Coroico, 5000 m., *Mandon*, 797 partim; inter Poto et Suchez, 4600 m., *Weberbauer*, 1002 *b*; Suchez, near boundary of Prov. Sandia, *Weberbauer*, 1019 (Mus. Bot. Berol.); without precise locality, *Bang*, 1964 (2) (Herb. Kew.).

Peru: Dep. Huancavelica, Cord. Huaytara, 4100 m., *R. Pearce* (Herb. Kew.; Herb. Mus. Paris.).

This species and *N. purpurascens* have been distributed under the no. 797, Mandon, and the same mistake occurs in the Paris Herbarium. The species is closely allied to *N. anthemidifolia*, but differs especially in the covering of greyish-white velvety hairs to the calyx and in the larger flowers; it is quite distinct from *N. purpurascens*. It also appears to be closely allied to *N. cinerea*, with which it was distributed under the no. 1964, Bang; the latter species is distinguished in being covered all over with a fine dusty felt of stellate hairs.

51. Nototriche anthemidifolia, A.W. Hill.—*Fruticulus* depressus, cæspitosus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* rosulatim disposita; petiolus circa 2 cm. longus; stipulæ petiolo infra medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera membranacea filiformi acuta circa 7 mm. longa, uti vagina facie et ad margines dense setoso-ciliata in dorso glabra; petiolus supra stipulas sulcatus, plus minusve glaber; lamina ambitu ovata vel ovato-oblonga, pinnatifida vel bipinnatifida, 1–2 cm. longa, supra stellato-tomentosa, infra plus minusve glabra, lacinulis brevibus lineari-oblongis obtusis integris subinde trifidis apice ciliatis. *Flores* infra petiolum medium insidentes. *Calyx* campanulatus, fere ad medium 5-lobus, lobis triangulari-acutis, circa 6 mm. longus, tubo glabro, lobis parce stellatis. *Corolla* rosea, 1·0–1·2 cm. longa; petala late obovato-cuneata, truncata vel retusa, basi in tubum circa 3 mm. longum coalita. *Carpella* 8–12, 3·5–4 mm. longa, subulato-birostrata, dorso sericeo-pilosa, pilis 6 mm. longis, rostris 2 mm. longis. *Semina* dorso rugosa.

Sida anthemidifolia, Remy, in Ann. Sc. Nat. sér. 3, vi. p. 356.

Nototriche discolor, Turcz. in Bull. Soc. Imp. Nat. Moscou, xxxvi. 1863, pt. i. p. 567.

Nototriche cheilanthifolia, Turcz. l. c. p. 567.

Malvastrum anthemidifolium, A. Gray, in Bot. U.S. Expl. Exp. p. 152; Weddell, Chl. And. ii. p. 282; Baker fil. in Journ. Bot. xxix. p. 364; Solms-Laubach, in Bot. Zeit. 1907, pp. 120, 130, Taf. 2. fig. 2.

Malvastrum saltense, K. Schum. in Nov. Act. Reg. Soc. Sc. Upsal. ser. 4, i. p. 127, non Hieron.

Bolivia: Alto de Tola, camino de Potosi à Oruro, *D'Orbigny*, 1357 (Pl. **30**. fig. 1); prope Lagunas de Potosi, *D'Orbigny*, 1354 (Herb. Mus. Paris.: Pl. **27**. fig. 8).

Peru: Cord. entre Puno et Arequipa, 4000 m., *Weddell*, 4446 (Herb. Mus. Paris.: Pl. **30**. figs. 31, 32).

Argentina: Prov. Jujuy, Dept. de Rinconada, Cuesta de San José, 4300 m., *F. Claren*, 11590 (Mus. Bot. Stockholm.).

Chili: Tacora, *Weddell* (ann. 1851) (Herb. Mus. Paris.); western Cord. Tacora, near Tacna, 4000–4500 m., *Steinmann*; without precise locality or collector (Herb. Kew.).

This species, which was one of the earliest known, is of some interest historically from having served as the type for two of the species of Turczaninow's genus *Nototriche* *, viz., *N. discolor*, Turcz., and *N. cheilanthifolia*, Turcz., founded on D'Orbigny's no. 1357 and no. 1354 respectively, though the former number had already been described by Remy as *Sida anthemidifolia* (Pl. 27. fig. 8). *N. anthemidifolia* is allied to some other species fairly closely, especially *N. saltensis* (Pl. 29. figs. 7, 8), *N. Mandoniana*, *N. velutina*, *N. longirostris*, and *N. pseudoglabra* (Pl. 29. fig. 5), &c.

The ripe fruits are known from Weddell's specimens from Peru (Pl. 30. figs. 31, 32), but not from the earlier specimens collected by D'Orbigny. A figure of the calyx and hairy vagina and stipules is given on Pl. 30. fig. 1.

As regards geographical distribution, this species inhabits Southern Bolivia, Peru, and N. Chili, and stretches into Argentina, which appears to be the home of *N. saltensis*, whilst the other allied forms are found in Southern Bolivia and Peru.

A figure of a leaf of a plant collected by Steinmann is given by Solms-Laubach †. Count Solms very kindly allowed me to see his specimen and I consider it to be *N. anthemidifolia* or a closely allied species, but owing to the youthful character of the leaf an exact determination was not possible.

52. NOTOTRICHE ARISTATA, A. W. Hill.—*Fruticulus* depressus, cæspitosus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* rosulatim disposita, viridia; petiolus circa 2 cm. longus; stipulæ petiolo supra medium adnatæ et cum eo quasi vaginam membranaceam 5 mm. latam formantes, parte libera membranacea late subulata acuta 5 mm. longa, uti vagina facie et in dorso glabra ad margines sparse setoso-ciliata; lamina ambitu plus minusve ovato-elliptica, palmatifida vel sub-bipinnatifida, 1·0–1·8 cm. longa, supra dense stellato-tomentosa, infra glabra, segmentis plus minusve confertis integris vel 3–7-fidis, lacinulis lineari-oblongis obtusis 3–4 mm. longis apice setoso-ciliatis. *Flores* ad petiolum medium insidentes. *Calyx* ad medium 5-lobus, circa 10 mm. longus, extus sparsissime ciliatus, lobis triangulari-acutis intus stellato-ciliatis. *Corolla* roseo-violacea, 1·6–1·8 cm. longa; petala spathulato-obovata, concava, basi in tubum 4–5 mm. longum coalita. *Stamina* pauca, in caput globosum instructa. *Carpella* 8–12, 8–9 mm. longa, subulato-birostrata, dorso setoso-ciliata, rostris 4·5 mm. longis.

PERU: Pacechac Valley, near Urubamba, 4500–5000 mm., *A. W. Hill*, 76, 77 (Herb. Kew.: Pl. 30. figs. 25, 26).

This species is like a large form of *N. longirostris*, but differs in the larger carpels with longer beaks and in their tomentum. In *N. longirostris* the carpel is covered on the back with short stellate hairs and the beak with longer and more bristle-like hairs (Pl. 30. fig. 22), whilst in *N. aristata* both the body of the carpel and the beak are covered with fairly long, stiff bristles (Pl. 30. figs. 25, 26).

53. NOTOTRICHE PEARCEI, A. W. Hill.—*Fruticulus* depressus, cæspitosus; caudex, subterraneus, lignosus, firmus, ramosus. *Folia* rosulatim disposita, viridia; petiolus

* A. W. Hill, in Eng. Bot. Jahrb. xxxvii. p. 577.

† Solms-Laubach, in Bot. Zeit. 1907, pp. 120, 130, Taf. 2. fig. 2.

ad 7 cm. longus; stipulæ petiolo supra medium adnatæ et cum eo quasi vaginam membranaceam formantes, parte libera herbacea lineari-acuta 8 mm. longa supra puberulo-stellato-tomentosa infra glabra, vagina et petiolo facie et in dorso glabris ad margines plus minusve stellato-pilosis; lamina ambitu oblongo-lanceolata, bipinnatifida, 1–2 cm. longa, supra sparse velutino-stellato-tomentosa, infra glabra, segmentis vicissim integris vel trifidis apice sparse ciliatis. *Flores* ad petiolum fere medium insidentes, breviter (1–3 mm.) pedicellati. *Calyx* tubuloso-campanulatus, circa 1·2 cm. longus, supra medium 5-lobus, lobis triangulari-acutis 4–5 mm. longis extus sparse stellatis intus albo-tomentosis. *Corolla* rosea, 2–2·5 cm. longa; petala obovata, retusa, 1 cm. lata, basi in tubum 2 mm. longum coalita. *Stamina* in caput oblongum instructa, filamentis liberis elongatis. *Carpella* matura non visa, rostris conspicuis, dorso longe ciliata.

Malvastrum Pearcei, Baker fil. in Journ. Bot. xxix. p. 364, partim.

PERU: Dep. Apurimac, Andahuaylas, 13,000–14,000 ft., *R. Pearce*; Huanta, *R. Pearce*, Feb. & April, 1867 (Herb. Kew., Herb. Brit. Mus.).

Two forms were included by Baker fil., in Journ. Bot. xxix. p. 364, under his species *Malvastrum Pearcei*. One of these from the Andes of Yungas, Bolivia, has been referred to *N. purpurascens*: the other, of which there are two collections, is retained in the species. The stipules are adnate to the petiole for about three-fourths of its length, with their free portions slightly recurved. The stellate hairs are only sparingly distributed over the upper surface of the lamina and the free portions of the stipules. In some of the specimens the petioles are considerably elongated, suggesting that these plants grow amongst grass or other plants and have been "drawn up."

This species in its leaf-form shows affinity to *N. aristata* and *N. longirostris* more particularly. As regards the floral characters, however, it is distinct in its short corolla-tube and elongated head of stamens with dark green anthers and long free filaments.

54. NOTOTRICHE PSEUDOGLABRA, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. p. 586.

AUSTRO-BOLIVIA: Puna Patanca, 3800 m., *Fiebrig*, 3186 A (Herb. Berol.: Pl. 29. fig. 5).

The lamina when young is covered by a delicate stellate tomentum on the upper surface, which disappears as the leaves mature (Pl. 29. fig. 5). *N. saltensis* is similar in this respect and is perhaps fairly closely allied to this species. The vagina is ciliate as in *N. anthemidifolia*, but the original lateral lobes of the lamina are much more developed than in that species.

55. NOTOTRICHE SALTENSIS, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. p. 587.

Malvastrum saltense, Hieron. (in Herb.).

Malveopsis saltensis, O. Kuntze, Rev. Gen. Plant. iii. 2, 1898, p. 22.

ARGENTINA: Prov. Salta, Nevado del Castillo, *Hieronymus et Niederlein*, 41 (Pl. 29. figs. 7, 8).

The young leaves of this species have fairly long cilia in addition to the ordinary tomentum of stellate hairs, but as the leaves mature the cilia are usually shed (Pl. 29. figs. 7, 8).

56. NOTOTRICHE LONGISSIMA, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. p. 586.

PERU: Dep. Ancachs, Prov. Cajatambo, Cordillera nigra inter Ocros et Chonta, 4400 m., *Weberbauer*, 2785 (Herb. Berol.: Pl. **27.** figs. 9, 10; Pl. **30.** fig. 24).

The caudex appears usually to be unbranched in this species and the longest specimen measured 11·5 cm. in length (Pl. **27.** figs. 9, 10). The carpels, which are 9 mm. long, are provided with beaks, 4 mm. long, covered with short cilia (Pl. **30.** fig. 24).

This species appears to be allied to *N. Pearcei*, which, however, is distinguished by its larger flowers and the more definite central portion of the lamina. The tomentum is also different in character.

57. NOTOTRICHE GLAUCA, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. p. 586.

AUSTRO-BOLIVIA: Puna Patanca, 3700–4000 m.; Es-Che-Mokro, 4200 m., *Fiebrig*, 3186 (Herb. Berol.: Pl. **29.** fig. 6).

The leaf-lobes are short, broad, and crenate (Pl. **29.** fig. 6), and covered on both sides with a soft dusty tomentum, showing some resemblance to *N. pedicularifolia*.

An imperfect specimen, Fiebrig, 3229, from the same locality, very possibly belongs to this species.

58. NOTOTRICHE CASTELNÆANA, A. W. Hill.—*N.* acaulis undique canescenti-tomentosa, caudice plus minus crasse, simplice vel parce ramoso, nudo; foliorum petiolo parum dilatato, limbo (10–20 mm. longo) pinnatisecto, pinnulis (utrinque 4–6) 3–5-fidis, inferioribus majoribus, lacinulis lineari-oblongis obtusis haud crispis utrinque cinereo-velutino-stellato-tomentosis; floribus petiolo medio vel paulo infra insidentibus, inter stipulas setaceas sessilibus; calycis campanulatis circa 9 mm. longis undique molliter tomentosis laciniis triangulari-lanceolatis tubum æquantibus; petalis (albidis?) calyce dimidio longioribus (circa 2 cm. longis), vix emarginatis; carpellis immaturis.

Malvastrum Castelnæanum, Wedd. Chl. And. ii. p. 283, tab. 80 A; Baker fil. in Journ. Bot. xxix. p. 364.

PERU: Cord. de Cuzco, *F. de Castelnau* (ann. 1842) (Herb. Mus. Paris.); Andes of Peru, *Maclean* (Herb. Kew.); "Sida sp. nova alpina del Peru" (ex Herb. Pavon. in Herb. Mus. Brit.).

The material of this species is so scanty that it has not been found possible to examine the specimens in detail, and there is very little to add to the description given by Weddell, which is here reproduced with slight alterations.

59. NOTOTRICHE CINEREA, A. W. Hill.—*Fruticulus* depressus, cæspitosus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* rosulatim disposita, cinerea; petiolus circa 2 cm. longus; stipulæ petiolo ad medium adnatæ et cum eo quasi vaginam formantes, parte libera lineari-subulata membranacea facie in dorso et ad margines ciliata; petiolus cum vagina facie et in dorso plus minusve stellato-puberulentus; vagina ad basim glabra, ad margines stellato-ciliata; lamina ambitu oblongo-ovata, bipinnatifida, 1·5–2 cm. longa, 1·3–1·5 cm. lata, supra dense, infra sparse puberu-

lento-stellato-tomentosa, segmentis pinnatifidis vel integris, lacinulis integris—raro trilobis—ovato-oblongis acutis apice piliferis. *Flores* paulo infra petiolum medium insidentes. *Calyx* ad medium 5-lobus, circa 1·1 cm. longus, lobis triangulari-oblongo-ovatis obtusis, extus dense cinereo-puberulento-tomentosus. *Corolla* violacea, circa 1·5 cm. longa; petala obovato-oblonga, basi in tubum 4 mm. longum coalita. *Carpella* vix matura, 5 mm. longa, birostrata, rostris 2 mm. longis, dorso pilifera.

BOLIVIA: *Bang*, 1964, 1 (Herb. Kew.; Herb. Berol.).

This species is characterised by the ashen-grey tomentum of fine stellate hairs which covers all the green parts of the plant. Two species were sent out under the no. 1964, Bang, the other being *N. Mandoniana.*

N. cinerea agrees closely with both *N. Mandoniana* and *N. anthemidifolia* as regards the form and lobation of the lamina, but differs in the character and distribution of the tomentum.

60. NOTOTRICHE ACUMINATA, A. W. Hill.—*Fruticulus* depressus, cæspitosus; caudex subterraneus, lignosus, firmus. *Folia* rosulatim disposita, incano-sericea; petiolus 2–3 cm. longus; stipulæ petiolo infra medium adnatæ et cum eo quasi vaginam membranaceam 4–5 mm. latam formantes, parte libera membranacea lineari-lanceolata acuta 5 mm. longa, uti petiolus facie sericeo-ciliata in dorso glabra; lamina ambitu triangularis vel cordata, bipinnatifida, circiter 1·0–1·2 cm. longa, 1·0–1·2 cm. lata, supra sericeo-tomentosa, infra glabra, segmentis infimis 3–5-lobis, superioribus 3-lobis vel integris, lobis lineari-oblongis obtusis. *Flores* infra petiolum medium insidentes. *Calyx* ad medium 5-lobus, lobis triangulari-acuminatis, 7–9 mm. longus, tubo glabro, lobis glabris vel pilis sericeis paucis instructis. *Corolla* rosea, 1·7–2·0 cm. longa; petala obovata, retusa, basi in tubum 5–6 mm. longum coalita. *Stamina* in caput globosum instructa, filamentis liberis longis. *Carpella* 3 mm. longa, breviter birostrata, dorso ciliata, pilis 4 mm. longis.

PERU: Andes of Ayacucho, 3600–4000 m., *R. Pearce* (May, 1867); Cordillera de Puno, *Lechler*, 1713 (Herb. Kew.).

This species in some respects resembles *N. anthemidifolia*, but differs especially in the triangular outline of the lamina and in the long soft silky hairs of the upper surface.

Hairs of this type are found also in *N. argentea* and in *N. sericea*. To this latter species *N. acuminata* appears to be very closely allied.

61. NOTOTRICHE SERICEA, A. W. Hill.—*Fruticulus* depressus, cæspitosus; caudex subterraneus, lignosus, firmus, ramosus. *Folia* rosulatim disposita, incano-sericea; petiolus ad 3 cm. longus; stipulæ petiolo circa ad medium adnatæ et cum eo quasi vaginam membranaceam circa 2 mm. latam formantes, parte libera membranacea subulato-filiformi circa 1 cm. longa, uti vagina facie et ad margines dense sericeo-ciliata in dorso glabra; petiolus supra stipulas facie sparsissime ciliatus, in dorso glaber; lamina ambitu triangulari-ovata, palmatifida, segmentis pinnatifidis vel

bipinnatifidis, supra plus minusve dense infra sparsissime sericeo-tomentosa, lobis integris vel 3–5-fidis, lacinulis ultimis numerosis anguste linearibus obtusis. *Flores* ad petiolum medium insidentes, brevi—2–3 mm.—pedicellati. *Calyx* supra medium 5-lobis, 8–9 mm. longus, lobis triangulari-acutis vel acuminatis 3–4 mm. longis extus et ad margines sparse sericeo-ciliatis, tubo glabro. *Corolla* cæruleo-violacea, 1·4–1·7 cm. longa; petala obovato-cuneata, retusa, basi in tubum 4–5 mm. longum coalita. *Stamina* pauca in caput globosum instructa, filamentis liberis longis; antheræ minutæ. *Carpella* circa 13, fere matura, birostrata, circa 4 mm. longa, dorso sericeo-ciliata, rostris circa 2 mm. longis.

PERU: Crucero Alto, summit of Arequipa—Puno railway, 4470 m., *A. W. Hill*, 82 (Herb. Kew.: Pl. 29. figs. 9, 10).

Distinguished from other species by its silky grey appearance and the numerous linear segments of the leaves (Pl. 29. figs. 9, 10). The stellate hairs are sessile and have only 2–4 long silky arms arising from each node. It is distinct from *N. acuminata*, particularly in the very small size of the anthers and in the distribution of the tomentum on the lamina.

62. NOTOTRICHE ARGENTEA, A. W. Hill, in Engl. Bot. Jahrb. xxxvii. p. 585.

PERU: Dep. Ancachs, Cordillera nigra supra Caraz, 4400–4500 m., *Weberbauer*, 3103 (Pl. 29. fig. 1); Prov. Cajatambo, Ocros ad Chonta, 4400 m., *Weberbauer*, 2777 (Herb. Berol.); without precise locality, *Maclean* (Herb. Kew.).

A very distinct species, owing to the dense silvery coating of silky hairs all over the plant (Pl. 29. fig. 1).

SPECIES IMPERFECTLY KNOWN.

With regard to the following species considerable uncertainty exists. No specimens have been examined, and as the descriptions are not very concise and definite it seems best not to attempt to reduce them to other known species.

SIDA PINNATA, Cav. Icon. v. p. 13, t. 422, fig. 1; DC. Prodr. i. p. 466.

Sida pinnata, Cav., doubtfully of Presl, Rel. Hænk. p. 111; doubtfully *Malvastrum pinnatum*, A. Gray, in Bot. U.S. Expl. Exp. p. 154; Wedd. Chl. And. ii. p. 281; Baker fil. in Journ. Bot. xxix. p. 365 (*Matthews*, 682 exclus.).

ECUADOR: in radicibus altissimis montis Chimborazo, ibique *Sida phyllanthos*, Cav.

Although Cavanilles gives a figure of his species *S. pinnata*, it is not possible to be certain of his plant, owing to the lack of detail in the drawing. It seems unlikely that plants collected in Peru, near Lima, are of the same species as those from Ecuador; and for this reason it seems best not to follow Gray, Weddell, and Baker fil., in placing either Gay's plant from the Cordillera of Cuzco or Pickering's plant from Casa Cancha under this species. The form collected by Matthews from Cerro Pasco (no. 682), placed

by Baker under this species, has been separated and described as a new species, *Nototriche Matthewsii*, to which perhaps the other Peruvian specimens may belong (p. 248). It also seems likely that the *Sida pinnata* of Presl, said to come from Peru, is not the *S. pinnata*, Cav.

SIDA ACAULIS, Cav. Icon. v. p. 13, t. 422. fig. 2; DC. Prodr. i. p. 466.

Malvastrum Cavanillesii, A. Gray, in Bot. U.S. Expl. Exp. p. 156, partim.

ECUADOR: in radicibus altissimi montis Chimborazo, *Cav.*

MALVASTRUM CAVANILLESII, A. Gray, in Bot. U.S. Expl. Exp. p. 156 (*Sida acaulis* exclus.); Wedd. Chl. And. ii. p. 281; Baker fil. in Journ. Bot. xxix. p. 364.

PERU: High Cordillera near Casa Cancha, *Pickering.*

The specimen collected by Pickering is referred by Gray to *Sida acaulis*, Cav., and he has been followed in this determination by Weddell and Baker fil. The original specimen was not seen, but he says "our specimen closely resembles the figure given by Cavanilles, but the corolla does not appear to have been yellow." As in the case of *S. pinnata*, Cav., it seems unlikely that the specimens from Peru and Ecuador belong to the same species, it will be better to retain the name *Sida acaulis*, Cav., for the species from Ecuador and to confine the name *M. Cavanillesii* to the Peruvian specimen until the two plants have been seen and compared.

MALVASTRUM STIPULARE, Phil. Viaje à la Provincia de Tarapacá, p. 8. n. 34; Baker fil. in Journ. Bot. xxxii. p. 36; Reiche, Fl. Chile, i. p. 235.

CHILI: Prov. Tarapacá, Machuca, Febrero, *Philippi.*

SIDA MEGALORRHIZA, Phil. Flor. Atacama, p. 11, n. 46.

Malvastrum megalorrhizum, Baker fil. in Journ. Bot. xxix. p. 363; Reiche, Fl. Chile, i. p. 236.

CHILI: Prov. Atacama, Alto de Paguios, 4150 m., *Philippi.*

MALVEOPSIS PICHINCHENSIS, O. Kuntze, var. DECOLORANS, O. Kuntze, in Rev. Gen. Plant. iii. 2, p. 21.

BOLIVIA: Tunarigebirge, 5000 m.

It seems unlikely, judging from the locality, that this plant can be a variety of *Nototriche pichinchensis*; the description, which only relates to the colour of the flowers, is too meagre to afford any clue as to the nature of this variety or species.

Bibliography.

Baker, E. G. Synopsis of Genera and Species of Malveæ. Journ. Bot. xxix. (1891) pp. 362–365.

Bentham, G. Plantæ Hartwegianæ, p. 164.

Candolle, A. P. de. Prodr. i. p. 466.

Cavanilles, A. J. Icones, v. p. 13, t. 422. figs. 1 & 2.

—— Diss. v. pp. 276, 277, t. 127. fig. 4.

Fries, R. E. Zur Kenntniss der alpinen Flora in nördlichen Argentinen. Nov. Act. Soc. Reg Scient. Upsaliensis, ser. 4, vol. i. 1905, p. 127.

Gay, C. Flora Chile, i. p. 329.

Gray, Asa. Botany of the United States Exploring Expedition, Phanerogamæ, 1854.

Hemsley, W. B., & H. H. W. Pearson. A small Collection of Dried Plants obtained by Sir Martin Conway in the Bolivian Andes. Journ. Linn. Soc., Bot. xxxv. (1901) pp. 78–90.

Hieronymus, G. Engl. Bot. Jahrb. xx. Beibl. no. 49, 1895, pp. 42–44.

—— Engl. Bot. Jahrb. xxi. 1895, pp. 318–320.

Hill, A. W. Notes on a Journey in Bolivia and Peru around Lake Titicaca. Scott. Geogr. Mag. 1905, pp. 249–259.

—— Note on the Genus *Nototriche*, Turcz. &c. Engl. Bot. Jahrb. xxxvii. 1906, pp. 575–587.

Humboldt, F. H. A. v., & A. Bonpland. Pl. Æquin. ii. pp. 115–117, tab. 116.

Humboldt, F. H. A. v., A. Bonpland, & C. S. Kunth. Nov. Gen. et Spec. v. p. 264.

Kuntze, Otto. Rev. Gen. Plant. iii. 2, 1898, p. 22.

Mandon, G. Première liste des plantes, &c. Bull. Soc. Bot. Fr. xii. 1865, p. 82.

Meyen, F. J. F. Reise um die Erde, vol. i. p. 460, vol. ii. p. 31.

Philippi, R. A. Reise durch die Wüste Atacama : Florula Atacamensis, p. 11.

—— Verzeichniss der von Friedrich Philippi auf der Hochebene der Prov. Antofagasta und Tarapacá gesammelten Pflanzen, 1891, pp. 8–9 (Viaje à la Prov. de Tarapacá).

Reiche, C. Flora Chile, i. pp. 234–236.

Remy, J. Analecta Boliviana, &c. Ann. des Sc. Nat. Bot. sér. 3, vi. 1846, p. 356; sér. 3, viii. 1847, p. 238.

Schumann, K. Nov. Act. Reg. Soc. Sc. Upsal. ser. 4, i. p. 127.

Spruce, R. Notes of a Botanist on the Amazon and Andes, 1908, vol. ii. p. 264.

Solms-Laubach, H. Graf zu. Ueber eine kleine Suite hochandiner Pflanzen aus Bolivien, &c. Bot. Zeit. 1907, pp. 119–138, with plate.

Turczaninow, N. Bull. de la Soc. Imp. Nat. de Moscou, xxxvi. 1863, pt. i. pp. 567, 568.

Ulbrich, E. *Nototriche Meyeni*, Ulbrich. Engl. Bot. Jahrb. xlii. 1908, p. 120.

Veitch, J. E. Hortus Veitchii, pp. 37–40.

Walpers, W. G. Meyenii obsequiæ botanicæ. Nov. Act. Acad. Cæs. Leop.-Carol. Nat. Cur. xix. Suppl. i. p. 308.

Weberbauer, A. Anatomische und biologische Studien über die Vegetation der Hochanden Perus. Engl. Bot. Jahrb. xxxvii. 1905, pp. 60–94.

—— Weitere Mitteilungen über Vegetation und Klima der Hochanden Perus. Mit Taf. 4 und 5. Engl. Bot. Jahrb. xxxix. 1907, pp. 449–461.

Weddell, H. A. Chloris Andina, ii. pp. 277–283, pl. 80.

Whymper, E. Travels among the Great Andes of the Equator, 1892.

EXPLANATION OF THE PLATES.

Of the photographs on Pl. 27. figs. 6 & 8 were kindly taken by Mr. Boodle from the sheets lent by the Director of the Herbarium, Museum d'Histoire Naturelle, Paris. The drawings, with the exception of figs. 6 & 15, Pl. 28, and figs. 1–5, 15, 16, Pl. 29, have been made by the Author. Figs. 7–10 18, 20, 21, Pl. 29, are taken from photographs.

Plate 27.

Fig. 1. *N. turritella.* Surface view of a small plant, showing eight cylindrical branches densely clothed with leaves; flowers are seen protruding from the flat surfaces; the individual leaves consisting of numerous lobulæ are well shown. (*Cf.* Pl. 28. figs. 11, 16, and text-fig., p. 202.) (A. W. Hill, 81.)

Fig. 2. The same plant seen from the side; only the light upper portions of the branches project above the soil. The lower portion is protected by the persistent vaginæ; below, the scars of leaf bases are visible and the root shows wrinkling.

Fig. 3. *N. Azorella.* A small piece of the densely-branched hard cushion. The branches are clothed with the persistent vaginæ, and at the apex of each a rosette of minute leaves can be seen with a single centrally-placed flower. A single branch is from 1–1·5 cm. in diameter. (*Cf.* Pl. 28. fig. 15.) $\frac{3}{4}$ nat. size. (Weberbauer, 957.)

Fig. 4. *N. pedatiloba.* A whole plant showing leaf-scars and root-shortening; the leaf-laminæ, composed of numerous lobulæ, are densely hairy on the upper surfaces. (A. W. Hill, 78.) (*Cf.* Pl. 28. fig. 12.) Nat. size.

Fig. 5. *N. pedicularifolia.* Showing the palmatisect leaf-lamina with its crisped, pinnatifid or bipinnatifid segments; in the open flower the long narrow petals can be seen. (Herb. Kew.) $\frac{3}{4}$ nat. size. Probably the type of *N. incana*, Turcz.

Fig. 6. *N. argyllioides.* A specimen collected by Weddell; formerly considered by him to be *Malvastrum ulophyllum*, A. Gray. The somewhat indefinitely palmatifid laminæ should be noted and compared with fig. 7. Sometimes the leaf-lamina is more or less oval in outline and deeply lobed. (Weddell, 4394.)

Fig. 7. *N. argyllioides.* A well-developed specimen of my own collection to compare with fig. 6. The leaves show various stages from a palmatisect type with equal segments towards a bipinnate type with the median lobe strongly developed. The adnation of the pedicels and stipules to the petioles is well shown. The tomentum is on the upper surface of the leaves, and is composed of very fine stellate hairs, giving the plant a grey dusty appearance. (A. W. Hill, 80.) ×1½.

Fig. 8. *N. anthemidifolia.* A plant in surface view, showing the bipinnatifid leaves with a stellate tomentum on the upper surface. The vaginæ are provided with long silky stellate hairs, which are seen in the centre of the specimen. (*Cf.* Pl. 30. fig. 1.) (D'Orbigny, 1354, Herb. Mus. Paris.)

This plant is the type of *N. cheilanthifolia*, Turcz., and is the same as D'Orbigny, 1357, the type of *N. discolor*, Turcz. Both had been previously named *Sida anthemidifolia*, Remy.

Fig. 9. *N. longissima.* In side view, showing the bipinnatifid leaves with few segments and the adnation of the stipules and petioles. ($\frac{1}{2}$ nat. size.)

Fig. 10. The same. The calyx on the left is full of ripe carpels, the hairs of which are seen protruding. (Weberbauer, 2785.)

Plate 28.

(Unless otherwise stated, the natural size of the leaf is indicated at the side of each drawing.)

Fig. 1. *N. ulophylla.* Leaf drawn from the original specimen in the Gray Herbarium, Harvard (Pickering). The median segment is trilobed and the lobes of some of the other segments are again lobed.

Fig. 2. *N. obcuneata.* The segments bear simple infolded lobes. The fine stellate tomentum, which covers the upper surface of the lamina, is only shown in a few places. (Weberbauer, 983.)

Fig. 3. *N. clandestina.* The lamina is reduced to a small obovate or spathulate organ. (Philippi, 86.)

Fig. 4. *N. pulvilla.* The lamina resembles that of *N. obcuneata*, but the median segment is trilobed at the apex; the stipules are filiform, and the hairs are much longer than in that species. × 4. (Hieronymus, 688.)

Fig. 5. *N. Hieronymi.* The lobulæ are somewhat fleshy and covered with a fine pulverulent tomentum. × 5. (Hieronymus, 853.)

Fig. 6. *N. artemisioides.* A leaf with flower; the segments of the lamina are regularly 3-lobed. × 1½. (Weberbauer, 4068.)

Fig. 7. *N. famatinensis.* The segments of the lamina are divided into numerous narrow lobulæ. There is a dense tomentum on the upper surface and a sparse tomentum on the lower surface of the lamina. × 3. (Hieronymus and Niederlein, 814.)

Fig. 8. *N. Lobbii.* The deeply-dissected lamina is cut into numerous segments, everywhere covered with a soft velvety tomentum. Nat. size. (Lobb.)

Fig. 9. *N. Meyeni.* Deeply-dissected lamina with few spathulate segments; the stipules are broad and obtuse. (Meyen.)

Fig. 10. *N. parviflora.* Leaf and calyx, the peduncle adnate for a short distance only; the lobes are cuneate. (Philippi.)

Fig. 11. *N. turritella.* Leaf and flower in bud, the peduncle adnate for a short distance only; the leaf lobulæ are felted together by a dense mass of hairs; the upper surface of the stipules is glabrous, the calyx covered with hairs. (A. W. Hill, 81.) *Cf.* fig. 16 and Pl. 27. figs. 1 & 2.

Fig. 12. *N. pedatiloba.* The lamina is divided into about fifty slightly fleshy lobulæ, hairy on the upper surface; the stipules are very broad and membranous. (A. W. Hill, 78.) *Cf.* Pl. 27. fig. 4.

Fig. 13. *N. dissecta.* The lamina is regularly divided in a tripartite manner and covered with long stellate hairs. (Pearce.)

Fig. 14. *N. sajamensis.* Back view of the lamina, showing the numerous "packets" of lobulæ closely felted together; the filiform stipules are adnate to the base of the lamina. × 4. (Stübel, 5 i.)

Fig. 15. *N. Azorella.* Leaf and flower. Note the minute lamina and broad vagina. In the flower only stamens could be found. × 4. (Weberbauer, 957.) *Cf.* Pl. 27. fig. 3.

Fig. 16. *N. turritella.* Surface view of a lamina. There appear to be three main segments much dissected. The lobulæ are arranged with their upper surfaces turned inwards and are densely felted together. (A. W. Hill, 81.) *Cf.* fig. 11 and Pl. 27. figs. 1 & 2.

Plate 29.

Fig. 1. *N. argentea.* Leaf and flower. The whole plant is covered with a silvery, silky tomentum of long stellate hairs. × 2. (Weberbauer, 3103.)

Fig. 2. *N. flabellata.* The lamina is only divided to the middle; the lobes to the segments are short and slightly crisped, the whole plant being covered by a soft velvety tomentum. × 1½. (Weberbauer, 961.)

Fig. 3. *N. sulphurea.* A somewhat irregularly shaped leaf. The median lobe is well developed and shows a bipinnate character; one of the filiform stipules is shown. × 2. (Weberbauer, 963.)

Fig. 4. A piece of the same, more highly magnified, to show the many-rayed stellate hairs which cover the whole plant with a dense woolly tomentum.

Fig. 5. *N. pseudoglabra.* A pinnate type of lamina, with the lateral lobes still strongly developed, glabrous in the adult condition; the vagina and stipules ciliate. × $1\frac{1}{2}$. (Fiebrig, 3186 A.)

Fig. 6. *N. glauca.* Pinnate type of lamina, with the segments of more or less equal value; the lobes are broad and obtuse; stipules filiform, covered all over with glaucous velvety tomentum. × 2. (Fiebrig, 3186.)

Fig. 7. *N. saltensis.* Young leaf showing the lamina, vagina and subulate stipules covered with a ciliate tomentum.

Fig. 8. An old leaf of the same species, with a calyx enclosing nearly ripe fruits; the pinnate type of the lamina is well seen—at this stage it is almost glabrous. Slightly less than nat. size. (Hieronymus and Niederlein, 41.)

Fig. 9. *N. sericea.* Leaf with calyx showing the lamina finely cut into narrow segments, with a tomentum of few-rayed silky stellate hairs.

Fig. 10. The same with flower, the leaf-cutting more plainly seen. Both nat. size. (A. W. Hill, 82.)

Fig. 11. *N. Matthewsii.* Leaf showing the development of the pinnate type of lamina from a 5-lobed leaf by the elongation of the median segment; the lobes are few, narrowly oblong, acute; the upper surface of the lamina is covered by a soft dense tomentum, and there are ciliæ at the apices of the lobes. × 3. (Matthews, 682.)

Fig. 12. *N. pichinchensis.* Showing the lamina cut to the middle, covered above by a soft velvety tomentum, glabrous and varnished below. × 2. (Jameson.)

Fig. 13. *N. Macleanii.* Lamina with broad stipules; the segments are cut nearly to the base of the lamina, the tomentum is composed of loose shaggy hairs. (Maclean.)

Fig. 14. *N. Hartwegii.* The cuneate lamina is cut to the middle into five segments, the median one only being 3-lobed; the tomentum is of loose shaggy hairs. × 2. (Hartweg, 918.)

Fig. 15. *N. aretioides.* The upper surface of the lamina and vagina; the lamina cut to rather below the middle lobes, concave, with a fairly dense shaggy tomentum on the upper surface.

Fig. 16. The same leaf showing the lower surface and the stiff stellate spines on the back of the vagina. × 4. (Weberbauer, 289.)

Fig. 17. *N. stenopetala.* The lamina showing the development of the pinnate type of leaf, from a leaf like that of *N. pichinchensis*; the lower surface is glabrous and varnished, the upper being covered by a velvety tomentum. × 2. (Maclean.)

Fig. 18. *N. lanata.* Leaf with young flower-bud, the five lobes are more or less pinnately lobed and the whole leaf is covered with a woolly tomentum.

Fig. 19. *N. pusilla.* Annual; the whole plant showing the more or less entire lamina with the stipules adnate to the bases of the leaves, except in the case of those to which the flowers are adnate. × 4. (Weddell, ann. 1847.)

Fig. 20. The same. Surface view of a plant showing the horizontal branches terminating in rosettes of leaves. About nat. size. (Weberbauer, 2788.)

Fig. 21. A small plant, side view, showing the root-system and two horizontal branches with their leaf-rosettes.

Fig. 22. *N. pygmæa.* Annual; the entire plant densely covered with hairs. × $1\frac{1}{2}$. (D'Orbigny, 1859.)

Fig. 23. A leaf with a flower and the filiform stipules: the leaf-segments show slight lobing; the corolla does not exceed the calyx-segments in length. × 7.

Fig. 24. The corolla cut open, showing the staminal column. × 7.

Plate 30.

Fig. 1. *N. anthemidifolia.* Calyx with a portion of the vagina and stipules showing the long silky hairs; the segments of the corolla are tomentose within and bear a few hairs on their outer surface. × 6. (D'Orbigny, 1357.)

Fig. 2. *N. obtusa.* The calyx split open to show the glandular nectaries at the base and the vascular system. × 3½. (Weberbauer, 2897.)

Fig. 3. *N. congesta.* A glandular patch with a vascular bundle more highly magnified, showing the mass of multicellular hairs seen from above. (Weberbauer, 1018.)

Fig. 4. *N. obtusa.* Three glandular multicellular hairs from a nectary: there is a single hemispherical apical cell, the other cells of the hair may be arranged in two or four rows.

Fig. 5. *N. pedatiloba.* The swollen calyx containing ripe carpels. (A. W. Hill, 78.)

Fig. 6. *N. turritella.* The corolla, with tube 5 mm. long, stellately hairy in the upper part; the numerous anthers are arranged in a globose head. (A. W. Hill, 81.)

Fig. 7. *N. flabellata.* A flower, showing the long column of stamens and styles hanging out on one side. Nat. size.

Fig. 8. The same, showing the corolla only; the corolla-tube is practically absent, the petals are irregularly toothed at the apex, the anthers are arranged in a globose head with long free portions to the filaments. × 2.

Fig. 9. *N. pichinchensis.* The base of the corolla and staminal column; the bases of the petals are covered with stellate hairs and the corolla-tube is practically absent; the anthers are arranged in a cylindrical head, the free portions of the filaments being very short. × 2.

Fig. 10. *N. pedatiloba.* The ripe carpels; in the lower part they are covered with stellate hairs, the beaks bearing fairly long cilia.

Fig. 11. *N. parviflora.* The carpel, with short beaks.

Fig. 12. *N. Meyeni.* The carpel, with short beaks.

Fig. 13. *N. turritella.* An immature carpel.

Fig. 14. *N. flabellata.* A carpel with long beaks and short stellate hairs. (Lechler, 1972, 1.)

Fig. 15. *N. Niederleinii.* Carpel showing the long bristle-like hairs all over the back and beaks. (Hieronymus, 690.)

Fig. 16. *N. pedicularifolia.* Carpel without beak and with long spirally twisted silky hairs. (D'Orbigny, 1356.)

Fig. 17. *N. coccinea.* The carpel has a short thick beak and the stellate hairs have only short arms.

Fig. 18. *N. argyllioides.* Carpel showing two kinds of stellate hair. (Weddell, 4394.)

Fig. 19. A seed from this species.

Fig. 20. *N. pedatiloba.* A single carpel (*cf.* fig. 10) showing short stellate hairs on the carpel proper and longer hairs on the beak.

Fig. 21. *N. flabellata.* Carpel with two types of hair.

Fig. 22. *N. longirostris.* Carpel showing the long beaks. (Gay.)

Fig. 23. Seeds of the same species in side and back view, showing the dorsal groove.

Fig. 24. *N. longissima.*

Fig. 25. *N. aristata.* Side view of the carpel with the contained seed.

Fig. 26. The same carpel split open, seen from the back, showing the distribution of the long bristle-like stellate hairs.

Fig. 27. *N. argyllioides.* A carpel showing the enclosed seed, to compare with fig. 18. (A. W. Hill, 80.)

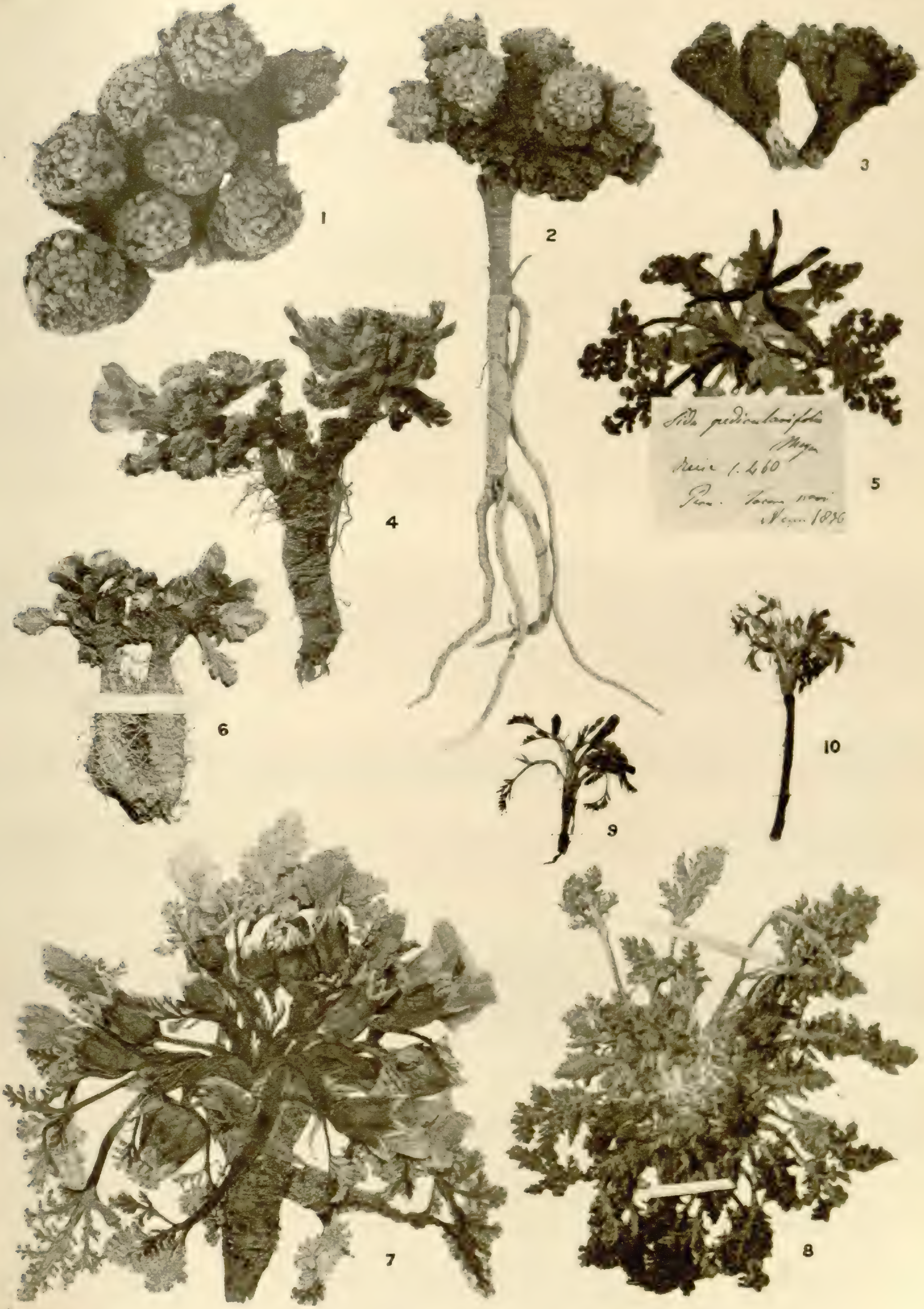
Fig. 28. *N. epileuca.* The beaks are broad and, like the rest of the carpel, bear short bristle-like hairs.

Fig. 29. *N. pusilla.* Very small carpel entirely filled by the seed, showing a short beak and covered with short stellate hairs.

Fig. 30. *N. pygmæa.* The beak is practically absent, the stellate hairs are only borne on the upper portion of the carpel.

Fig. 31. *N. anthemidifolia.* Showing the large carpel and the position of the seed; the beaks are short; the back of the carpel and the beaks are covered with long spirally twisted silky hairs. (Weddell, 4446.)

Fig. 32. The seed of this species.



Grout, sc.

The Genus NOTOTRICHE, Turcz.

SPECIES OF NOTOTRICHE, *Turcz.*

A. W. H. del
J. N. Fitch lith.

West, Newman imp.

SPECIES OF NOTOTRICHE, *Turcz.*

West, Newman imp.

SPECIES OF NOTOTRICHE, *Turcz.*

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s*. to the public, and 6*s*. to Fellows; to Vols. 26–30, 4*s*. to the public, and 3*s*. to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

SECOND SERIES.—BOTANY.

Volume.		When Published.	Price to the Public. £	*s.*	*d.*	Price to Fellows. £	*s.*	*d.*
I.	Parts I.–IX. (complete).	1875–80.	8	1	0	6	1	0
II.	Part I.	1881.	0	12	0	0	9	0
	Part II.	1882.	0	5	0	0	3	9
	Part III.	1883.	0	10	0	0	7	6
	Part IV.	1883.	0	3	0	0	2	3
	Part V.	1883.	0	3	0	0	2	3
	Part VI.	1884.	0	13	6	0	10	0
	Part VII.	1884.	0	9	6	0	7	0
	Part VIII.	1884.	0	10	0	0	7	6
	Part IX.	1886.	0	7	0	0	5	0
	Part X.	1887.	0	3	4	0	2	6
	Part XI.	1886.	0	6	0	0	4	6
	Part XII.	1886.	0	8	0	0	6	0
	Part XIII.	1887.	1	7	0	1	0	0
	Part XIV.	1887.	0	7	0	0	5	0
	Part XV.	1887.	0	10	0	0	7	6
	Part XVI.	1888.	0	2	6	0	2	0
III.	Part I.	1888.	3	12	0	2	14	0
	Part II.	1891.	0	5	0	0	3	9
	Part III.	1891.	0	7	0	0	5	0
	Part IV.	1891.	0	6	0	0	4	6
	Part V.	1891.	0	6	0	0	4	6
	Part VI.	1891.	0	3	6	0	2	8
	Part VII.	1892.	0	6	0	0	4	6
	Part VIII.	1893.	0	6	0	0	4	6
	Part IX.	1893.	1	8	0	1	1	0
	Part X.	1894.	0	10	0	0	7	6
	Part XI.	1894.	0	3	4	0	2	6
IV.	Part I.	1894.	1	0	0	0	15	0
	Part II.	1894.	2	0	0	1	10	0
	Part III.	1895.	2	10	0	1	17	0
	Part IV.	1895.	0	3	4	0	2	6
V.	Part I.	1895.	0	9	0	0	6	9
	Part II.	1895.	0	12	0	0	9	0
	Part III.	1896.	0	6	0	0	4	6
	Part IV.	1896.	1	0	0	0	15	0
V.	Part V.	1896.	0	14	0	0	10	6
	Part VI.	1896.	0	4	0	0	3	0
	Part VII.	1897.	0	4	0	0	3	0
	Part VIII.	1897.	0	6	0	0	4	6
	Part IX.	1899.	0	12	0	0	9	0
	Part X.	1899.	0	6	0	0	4	6
	Part XI.	1899.	0	7	0	0	5	0
	Part XII.	1899.	0	12	0	0	9	0
	Part XIII.	1900.	0	1	6	0	1	2
	Part XIV.	1900.	0	3	0	0	2	3
	Part XV.	1901.	0	6	0	0	4	6
VI.	Part I.	1901.	1	10	0	1	2	6
	Part II.	1901.	0	6	0	0	4	6
	Part III.	1902.	0	18	0	0	13	6
	Part IV.	1903.	0	8	0	0	6	0
	Part V.	1903.	0	8	0	0	6	0
	Part VI.	1903.	0	12	0	0	9	0
	Part VII.	1904.	0	12	0	0	9	0
	Part VIII.	1904.	0	12	0	0	9	0
	Part IX.	1904.	0	7	0	0	5	3
	Part X.	1904.	0	14	0	0	10	6
	Part XI.	1905.	0	4	0	0	3	0
VII.	Part I.	1904.	0	5	0	0	3	9
	Part II.	1905.	0	6	0	0	4	6
	Part III.	1906.	0	3	0	0	2	3
	Part IV.	1906.	0	7	0	0	5	3
	Part V.	1907.	0	10	0	0	7	6
	Part VI.	1907.	0	4	0	0	3	0
	Part VII.	1907.	0	6	0	0	4	6
	Part VIII.	1908.	0	5	0	0	3	9
	Part IX.	1908.	0	2	6	0	2	0
	Part X.	1908.	0	7	0	0	5	3
	Part XI.	1909.	0	4	0	0	3	0
	Part XII.	1909.	0	12	0	0	9	0

2nd Ser. BOTANY.] [VOL. VII. PART 13.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

THE LONGITUDINAL SYMMETRY OF THE CENTROSPERMÆ.

BY

PERCY GROOM, M.A., D.Sc., F.L.S.,
ASSISTANT PROFESSOR OF BOTANY, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, LONDON.

LONDON:

PRINTED FOR THE LINNEAN SOCIETY
BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,
AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

September 1909.

XIII. *The Longitudinal Symmetry of the* Centrospermæ. *By* PERCY GROOM, *M.A., D.Sc., F.L.S., Assistant Professor of Botany, Imperial College of Science and Technology, London.*

(26 Text-figures.)

Read 21st January, 1909.

IN my preliminary communication to the Linnean Society and my paper published in the 'Transactions' of the Royal Society (1908) I suggested a graphic method of recording the longitudinal distances apart of the successive leaves of a shoot. According to this method the successive segments of a stem are recorded on squared paper as successive ordinates, and the resultant curve is termed an "internode-curve."

The application of this method to a typical stem shows an unexpected regularity, and relative constancy, in the internode-curve in a species; the internode-curve of the main axis assumes an ascending-descending (normal) form, while those of the successive branches (proceeding from the base to the apex) exhibit a gradual change from the ascending-descending form to a purely descending one. But in the Chenopodiaceæ, while the opposite-leaved *Salicornia* shows typical internode-curves, the alternate-leaved types are characterized by peculiar zigzag internode-curves, which, when analysed by joining the alternate ordinates, each yield two regular or consistent subcurves. It was shown in my previous paper that the zigzag internode-curve is probably due to the longitudinal diremption of the originally opposite leaves at each of the nodes, and that the two subcurves represent respectively an internode-subcurve and a displacement-subcurve.

In the present paper are recorded additional observations showing the general prevalence of this type of longitudinal symmetry in the alternate-leaved Chenopodiaceæ. The observations concern: on the one hand, numbers of individuals of one species, and the different axes (primary to quaternary), in order to show the range of variation in one species and yet the universality of the two subcurves; and, on the other hand, additional species.

The fact that the Caryophyllaceæ are almost without exception opposite-leaved, and that the majority of the other families of the Centrospermæ include opposite- and alternate-leaved types or opposite-leaved types only, suggested that possibly the original phyllotaxis of the Centrospermæ as a whole was opposite in type, and that throughout the cohort the alternate phyllotaxis was derived from this by leaf-displacement. The present investigation is also designed to test this possibility.

Observations were made on Chenopodiaceæ, Caryophyllaceæ, Aizoaceæ. Amarantaceæ, Phytolaccaceæ, and Portulacaceæ.

In all these families, so far as my observations go, the internode-curves of the alternate-leaved types are irregular and zigzag, but are capable of analysis into two subcurves of greater or less regularity. The internode-curves of the opposite-leaved forms are much more regular and show more or less regularity of form. Thus the evidence points clearly in the direction of the opposite type of phyllotaxis as being the one originally characteristic of the whole cohort, and the alternate type as being derived from this by relative longitudinal displacement of the leaves.

Irregularities in the internode-curves and in the subcurves are due to two causes:—

(1) *Inherent causes,* as in the case, say, of the Chenopodiaceæ, where the recurrent zigzag is due to leaf-displacement; also in the case of branches where, as proved in my previous paper, a double maximum may arise as the internode-curve or subcurve changes from the normal type to the descending type by the relative or absolute increased length of the more proximal internodes or segments.

(2) *External causes,* such as changed supply of water, of light, of heat, and so forth.

At present no detailed observations have been made on the actual changes in the internode-curve occasioned by changes in the surroundings, though the characters of such may be inferred by comparing the internode-curves of the main stems, or of the corresponding branches, of one species. My published and unpublished observations of this nature render it safe to infer that sharp, sudden, and repeated irregularities of the internode-curves in the alternate-leaved Centrospermæ and other species where opposite and alternate phyllotaxis are represented in one genus or species are inherent, and are distinguishable from the occasional or more gradual irregularities that are due to external changes.

But I hope in the future to make more detailed observations on the modifications in longitudinal symmetry induced by external changes.

The Centrospermæ, apart from the structure of their flowers and phyllotaxis, display a number of morphological features common at least to several of the constituent families.

In some families there is a strong tendency for the axes to end in flowers and for the branching to be cymose: for instance, in the Caryophyllaceæ, Phytolaccaceæ, and Portulacaceæ. And the partial inflorescences or branching often assumes a dichasial form, tending towards a cincinnoid type by strengthening of one of the two branches, or may assume a purely cincinnoid form by non-development of the weaker branch. This cymose branching with the strengthening of one branch at a node reaches a climax in the Nyctaginaceæ. In the Chenopodiaceæ, Nyctaginaceæ, and some other families the emission of accessory branches is a very general feature.

In the inflorescence region the precocious development of branches is often associated with the "fusion" of branches with the main axis, as is especially seen in the Chenopodiaceæ, Phytolaccaceæ, and Portulacaceæ. Where the relatively main axis terminates in a flower as in the latter two cases, this fusion is associated with the pushing aside of the true end of the stem and the production of leaf-opposed or extra-axillary inflorescences recalling those of the Boraginaceæ. These "fusions" of the branches in the inflorescence-region, together with the leaf-displacements, are responsible for the formation

of "interrupted" inflorescences in the Chenopodiaceæ. Such "fusions" prepare us for the notorious fasciation of amarantaceous inflorescences.

But in other parts of the stem of Chenopodiaceæ where branches shoot out precociously similar "fusions" take place between branch and main axis or subtending leaf.

The remaining pages give particulars concerning the various families, genera, and species investigated.

CHENOPODIACEÆ.

The species investigated were *Atriplex rosea* (two forms), *Salsola Kali*, and *Chenopodium Bonus-Henricus*.

ATRIPLEX ROSEA. (Curves 1–5.)

The plants were collected on the sea-shore in Anglesey, where there were two varieties :—

(i.) The ordinary prostrate form whose main stem bends over parallel to the surface of the soil almost as soon as it emerges from the sand.

(ii.) An erect form of more slender build, usually found growing on the steeper slopes of the sand-hills on the seaward side farther from the sea than the gently sloping or level sand where the prostrate form abounds: yet the erect variety was not entirely lacking from the latter habitat, so that its difference from the prostrate form is not induced by external circumstances.

Most of my observations concern the more abundant prostrate form, and are of special significance because the open flatness of habitat and the prostrate method of growth reduce to a minimum differences of the various shoots as regards conditions of light, heat, and moisture.

Before discussing the internode-curves of this species some remarks may be offered concerning the phyllotaxis and mode of growth of seedlings and young plants of the prostrate form.

At first the hypogeal development far outstrips the epigeal, and a deep tap-root rapidly descends in the sand to the deeper-lying water, while a relatively short shoot is being produced (this is demonstrated by a comparison of the second and third columns in the following Table, p. 270). The early bending over of the main shoot and the prostrate condition of the branches remove the plant largely from the influence of the wind, also cause it to take a relatively small part in fixing the sand and to evade the danger of early burial.

The leaves at the base show a decussate design of phyllotaxis and are opposite or sub-opposite, as are the branches, which very early grow out horizontally, creep over the ground, elongate rapidly, and therefore soon equal or exceed in length the main stem (see the following Table). The rapid elongation of the branches in comparison with the stem is associated with the greater lengths of their first internodes, which tend to carry the leaves of the branches out of range of those on the main stem or the other branches.

The first branches to appear are either those in the axils of the first pair of foliage-leaves or, less frequently, of the cotyledons. Accessory branches are often produced beneath the true axillary ones, and in one case (seedling Y) arose in an interpetiolar position between the cotyledons. Associated with the early outgrowth of the basal branches are frequent fusions between these and the main axis or the subtending leaf. Higher up the leaves become more apparently alternate; the decussate divergence is lost. Nevertheless the divergence of the leaves of the seedling supplies evidence conforming with the view that the phyllotaxis was originally opposite: for instance, in specimen D 5 the cotyledons and the first four pairs of leaves showed perfect or approximate decussate divergence, though the pairs of leaves were not all opposite as regards height of insertion.

In the subjoined Table the numbers given are lengths in millimetres of the various stems which were still in active growth. Each horizontal line gives particulars concerning one seedling, the parts referred to being named at the heads of the vertical columns. The numbers in brackets beneath those recording the stem-lengths denote the length of the successive internodes. "Shorter" indicates that the branch was of length less than that of the branch at the immediately preceding node.

Name of the seedling.	Length of the hypocotyl and main root (broken at end).	Length of main stem.	Length of branches subtended by:							
			Cotyledons.		First pair of leaves.		Second pair of leaves.		Third pair of leaves.	
			I.	I'.	II.	II'.	III.	III'.	IV.	IV'.
D 3	76	10	bud.	bud.	bud.	bud.				
D 11 . .	. .	30 (4·5, 5·5, 8 . . . .)	young. (4 (young) . . . .)	young. (4 (young) . . . .)	30 (18·5 . . . .)	34 (21 . . . .)	shorter. (8 (young) . . . .)	shorter. (8 (young) . . . .)		
D 7	120	35 (6, 7·5, 8 . . . .)	bud.	bud.	30 (20 . . . .)	30 (20 . . . .)	shorter. (15 . . . .)	shorter. (15 . . . .)	bud.	bud.
D 5	125	40	bud.	bud.	bud.	55	shorter.	shorter.	bud.	bud.
Y (erect)	110	45	80 (50, 18, ...)	60 (40, 11, ...)	50 (30 . . . .)	50 (30 . . . .)	shorter.	shorter.	bud.	bud.
I_{34} K . .	. .	65	70	90	100	105	65	50	shorter.	shorter.
I_{30}	. .	110	bud.	bud.	190	160	125	145		
I_{10}	. .	165	bud.	bud.	185	175	225	195	155	
I_{38}	. .	164	bud.	short, young.	204	193	174	170	116	72

It will be noted that even in the seedling (Y) with an erect main stem the branches soon surpassed the main stem as regards length. This particular seedling possibly

represented a form transitional between the prostrate and erect form, as, despite of its erect main stem, the lowest two branches were prostrate, and the next two higher ones were slightly descending : moreover, in typical erect forms the branches emitted from the base of the main stem are less developed (at least early in life) than those inserted at some distance higher.

Internode-curves of Atriplex rosea.

Measurements were made along not only primary and secondary, but also tertiary and quaternary axes. They show the general truth of the following conclusions:—

1. The internode-curves are zigzag, and those of the branches are often also irregular, but can be analysed into two regular or consistent subcurves—internode-subcurve and displacement-subcurve.

2. The subcurves of the main axis and lower secondary axes are of the ascending-descending (normal) type, but in branches successively inserted higher up the axis they change towards a purely descending type; and in this change, thanks to the disproportionate gain in length of the proximal segments (early ordinates), an additional maximum (or minimum) is introduced into the subcurve. The subcurve recording the leaf-displacements usually undergoes the change later than the internode-subcurve.

These statements are proved by the subjoined statistics referring to specimens termed I 38, I 10, 191, 192, 187, I 12 Er^1, I 14 Er^3, I 18 Er^4, and represented by Curves 1–5.

Regular *Ascending-descending Subcurves* shown by :—

Nature of the axes.	Internode-subcurve.	Displacement-subcurve.
Main axes	I 38 (Curve 1 *m*).	I 38 (Curve 1 *m*).
Secondary axes ..	Relatively main axis of 192 (Curve 3 *m*).	I 38, Branches 1–4 (Curves 1 I, 1 II). I 10, Branches 1, 3, 4 (Curves 2 I, 2 II). 192, Relatively main axis (Curve 3 *m*). 191, „ „ (Curve 4 *m*).
Tertiary axes....	192, Branch 1 (Curve 3 I).	192, Branches 1, 2 (Curves 3 I, 3 II). 191, Branch 2 (Curve 4 I).
Quaternary axes .	....	187, A I (Curve 5 I).

Gradual Conversion of the Ascending-descending Subcurves to Descending Subcurves.

Nature of the axes.	Plant.	Internode-subcurves.			Displacement-subcurves.		
		a.	*b.*	*c.*	*a'.*	*b'.*	*c'.*
		Ascending-descending with lengthening of the lower (proximal) segments (earlier ordinates).	Showing double maximum due to gain in length of lowest or lower segments.	Purely descending curve of increasing steepness.	Ascending-descending with lengthening of the lower segments (earlier ordinates).	Showing double maximum due to gain in length of lowest or lower segments.	Purely descending curve of increasing steepness.
Secondary axes.	I 10	....	Branches 1–4 (Curves 2 I, 2 II).	Branches 5, 6 (Curve 2 III).	Branch 1 (Curve 2 I), Branches 3, 4 (Curve 2 II).	....	Branches 5, 6 (Curve 2 III).
	I 38	....	Branch 2 (Curve I I).	Branches 1, 3–6 (Curves 1 I–III).	Branches 1–4 (Curves 1 I–II).		
	191	....	Relatively main axis (Curve 4 *m*).				
Tertiary axes.	192	Branch 1 (Curve 3 I).	Branches 2, 3, 5 (Curves 3 II–IV).	Branch 5 accessory (Curve 3 V).	Branch 1 (Curve 3 I).	Branches 3, 5 (Curves 3 III–IV).	
	191	....	Branches 2, 4 (Curves 4 I, 4 II).	Branches 5, 7 (Curves 4 III, 4 IV).	Branches 2, 5 (Curves 4 I, 4 III).	....	Branches 4, 7 (Curves 4 II, 4 IV).
Quaternary axes.	187	....	Branches A 1, A 3 (Curves 5 I, 5 II).	Branches A 4, A 6 (Curve 5 III).	Branches A 1, A 3, A 4–6 (Curves 5 I, 5 II–IV).		

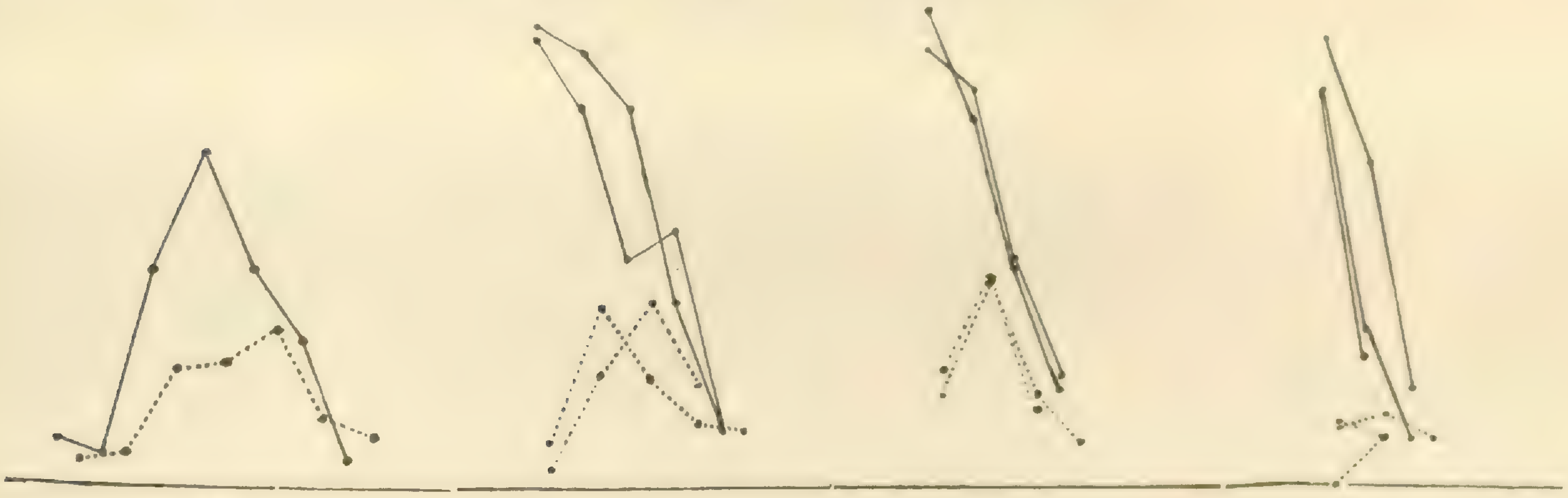
In the succeeding Tables the horizontal series of numbers represent the lengths in millimetres of the successive segments of an axis, the nature of which is indicated in the left-hand column. Branches springing from the axils of leaves actually or phylogenetically belonging to the same node are bracketed in the left-hand column. The branches are numbered successively upwards. The vertical columns, so far as they refer to measurements of branches, thus give means of comparing the lengths of corresponding segments of the successive branches.

Atriplex rosea I 34 K.

The following measurements were made :—

											Total length of shoot.
Main stem	3·7	1·5	10	3·5	11·5	6	11	0	8	Bud.	65
Basal Branch (I′)	47	1	11·5	·5	4	0	Bud.	..	..	..	70
,, ,, (I″)	49·5	3·5	17	4·5	6	0	3·5	Bud.	..	..	90
1st Branch (II)	58	6·5	11	9·5	5·5	2·5	Bud.	..	..	..	100
2nd ,, (II′)	62	1·5	17·5	5·5	5	·5	3·5	Bud.	..	..	105
3rd ,, (III)	44	3·5	8	2·5	4	Bud.	..	..	..	..	65
4th ,, (III′)	32	3	8	2·5	Bud.	..	..	..	..	..	50
Remaining higher branches	..	..	..	..	..	..	..	..	..	..	Shorter.

Atriplex rosea I 38. (Curves 1 *m*, 1 I–III.) †



1 *m*. 1 I. 1 II. 1 III.

																Total length of shoot.
Main stem	4·5	2·5	3	3	22	12*	34·5	12·5	22	16	15	7	2·5	5	Bud.	164
Basal (I)	Bud.															
,, (I′)	Short branch.															
1st Branch (II)	47·5	1·5	45	11·5	39	19	19	10·5	5·5	..	..	..	..	..	..	204
2nd ,, (II′)	46	4·5	39·5	18·5	23·5	11	26·5	6·5	5·5	5·5	..	..	..	..	..	193
3rd ,, (III)	45·5	9·5	41·5	21·5	24	9·5	11·5	4·5	..	..	..	..	..	..	..	174
4th ,, (III′)	49·5	12	38	22	23	8	10	..	..	..	..	..	..	..	..	170
5th ,, (IV)	47	6	34	7·5	10	5	..	..	..	..	..	..	..	..	..	116
5th* ,, (IV*)	41·5	0	16·5	5	5	..	..	..	..	..	..	..	..	..	..	72
6th ,, (IV′)	41·5	6·5	13·5	5	..	..	..	..	..	..	..	..	..	..	..	72

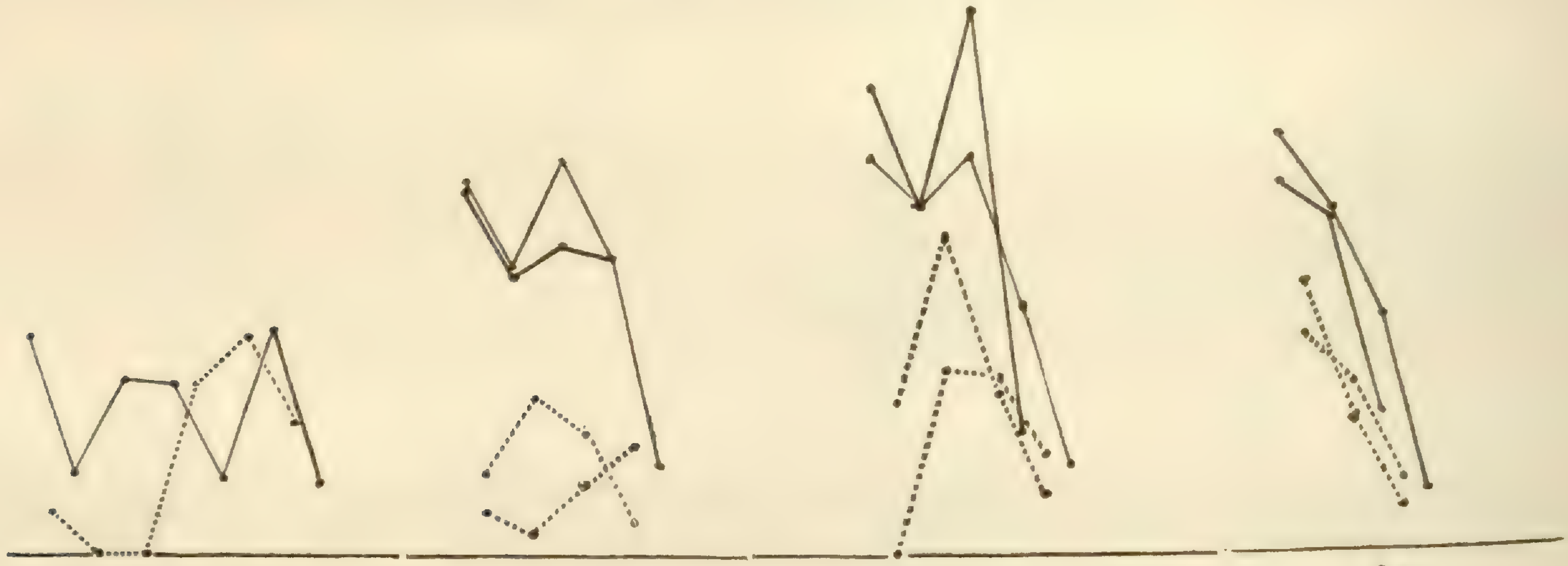
This specimen (I 38) showed a remarkable feature associated with the preservation of the decussate divergence at the base of the main shoot. The sixth measurement along

† For explanation of these and other curves, see pp. 300–302.

the main axis (12 mm.) represented the displacement of one leaf upwards from what would be the third node if the ancestral opposite phyllotaxis were preserved. There should therefore have been at the summit of the segment only one leaf, the upwardly displaced one, separated from its predecessor by 180°; this leaf was present but exactly opposite to it, and therefore exactly superposed on the immediately preceding leaf was another leaf (which subtended the branch termed 5th* (IV*)). The result is the same as if the original 3rd node, with leaves A and B, were first to produce leaf A, and then were to elongate and produce, higher up, not only leaf B, but also a repetition of leaf A superposed on this. It is of great interest to note that the branch subtended by this, so to speak, repeated leaf showed at its base a reversion to the original opposite phyllotaxis, but higher up a type of longitudinal symmetry resembling that of the 6th branch (IV′), which was inserted at the same level.

The subcurves of the branches show clearly how closely those of the successive pairs agree with each other but differ from those of their predecessors or successors.

Atriplex rosea I 10. (Curves 2 *m*, 2 I–III.)



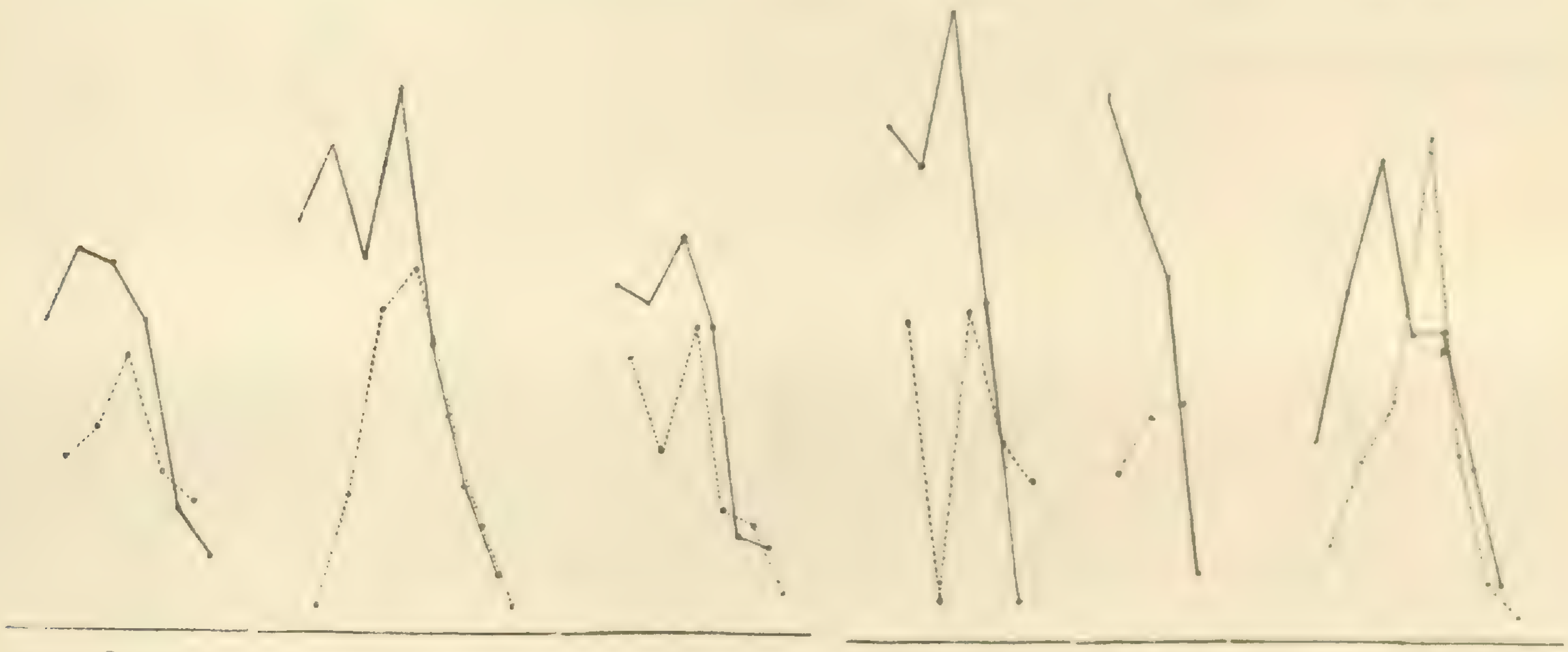
2 *m*. 2 I. 2 II. 2 III.

															Total length.
Main stem	22	4	8	0	17·5	0	17	17	7·5	22	22·5	13	7	Bud.	165
{ 1st Branch (II) ..	38	8	29	16	40	12	30	3	9	..	..	..	..	..	185
{ 2nd " (II′) ..	37	4	28	2	31·5	7	30	11	..	..	..	..	..	..	175
{ 3rd " (III) ..	47	15	35	32	55	16	12	6	Bud.	..	..	..	..	..	225
{ 4th " (III′) ..	40	0	35	18·5	40	18	25	10	9	Bud.	..	..	..	..	195
{ 5th " (IV) ..	42	22	35	17	24	7	6	..	..	..	..	..	..	..	155
{ 6th " (IV′) ..	37·5	27·5	34	13·5	14	4·5									
{ 7th " (V) ..	37	17·5	21	8·5	6	Bud.									
{ 8th " (V′) ..	(A dwarf shoot consisting of a cluster of flowers.)														
{ 9th " (VI) ..	28	6	8	Bud.											
{ 10th " (VI′) ..	26·5	6	6	Bud.											
11th " (VII) ..	15	Bud.													

Measurements along the main axis of specimen I 10 commenced at the cotyledonary node. After having its first pair of foliage-leaves separated by a distance of 4 mm., the main shoot showed a reversion to the exact opposite phyllotaxis at the next two nodes. The internode-subcurve of the main axis is unusually irregular: it is possible that the abnormal length of the first internode was due to the main stem being deeply buried (though I made no note at the time indicating such a condition).

The preliminary fall in the internode-subcurves of the first four branches, on the contrary, is easily explicable as representing a transition towards the purely descending form of curve which is attained in the 5th and 6th branches.

Atriplex rosea 192. (Curves 3 *m*, 3 I–V.)



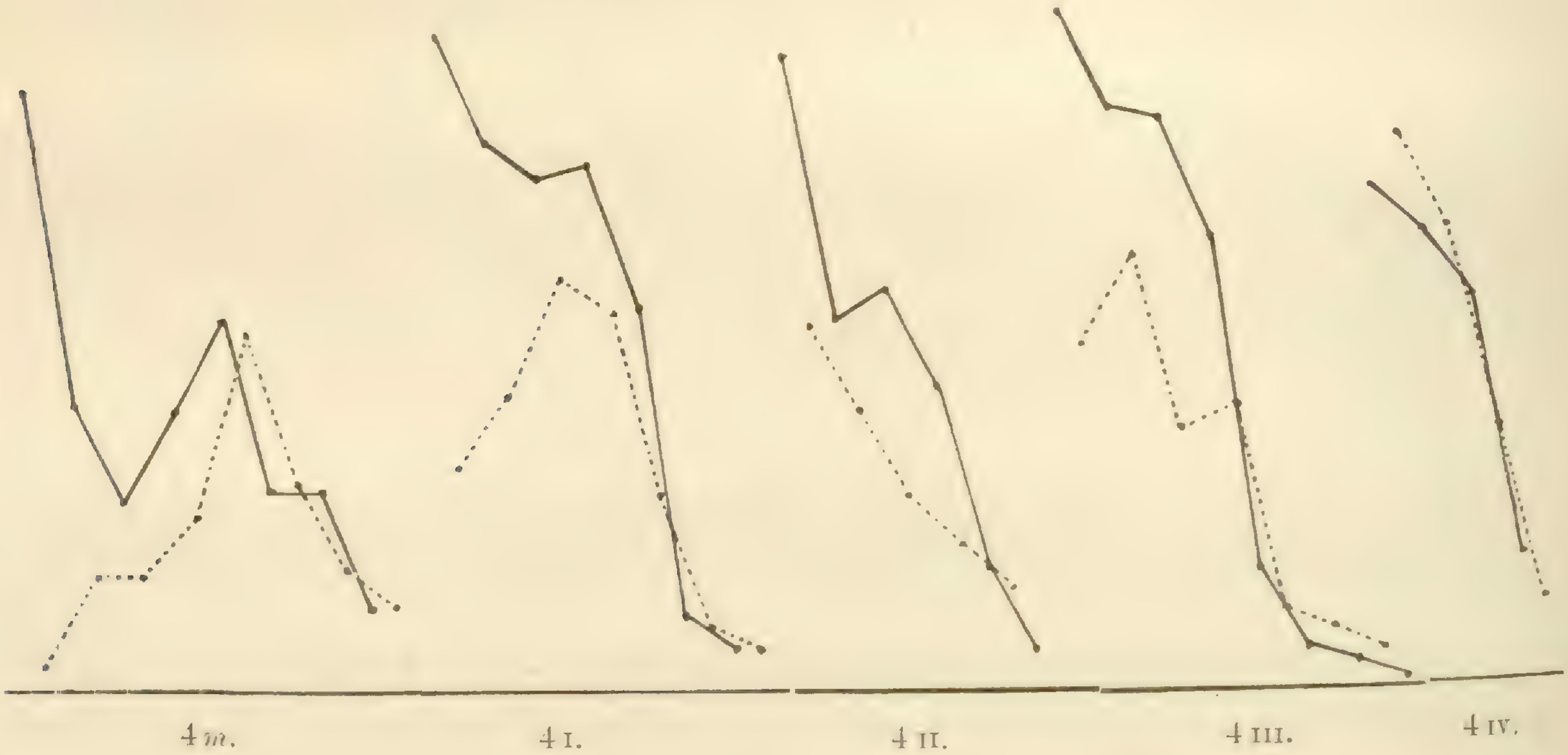
															Approximate total length.
Relatively main stem (Secondary)	*30·5*	14·5	*54·5*	27·5	*75*	37·5	*47·5*	79	*48·5*	29	*26·5*	9	*8·5*	4	492
1st Branch (Tertiary 1)	*48*	26·5	*59*	31·5	*57*	43	*48*	24·5	*19*	20	*12*	..	..	..	389
2nd " (" 2)	*64*	4·5	*76*	22	*58*	50·5	*84·5*	56·5	*45*	34	*23*	16·5	*9·5*	4	548
3rd " (" 3)	*54*	42·5	*51*	28	*61·5*	47·5	*47·5*	19·5	*15*	17	*13·5*	6·5	..	..	404
5th " (" 5)	*81*	50	*74·5*	6·5	*99*	51·5	*52·5*	31	*6·5*	25	..	..	..	..	478
5th accessory (Tertiary 5′)	*84·5*	26	*70*	35	*56·5*	37	*10·5*	..	..	..	..	..	..	..	320

In the case of specimen 192 the relatively main axis was a secondary axis. In addition to showing the change of symmetry of the successive tertiary axes, the specimen exhibited a number of "fusions" of the branches with relatively main axes, so that supra-axillary branches were inserted on certain of the tertiary axes. (The Branches are numbered successively upwards, and beneath the fifth branch in the axil of the same leaf was an accessory branch, which is termed "Vth accessory").

On Branch 2, the branch subtended by the seventh leaf was "fused" with the parent-axis for a considerable distance upwards; a ridge and two furrows clearly marked the outline of the "fused" part of the branch. The branch subtended by the ninth leaf was likewise displaced upwards, though in this case there was no such clear projecting ridge denoting the "fused" part of the branch; still, the supra-axillary position of this, the lack of any subtending leaf immediately beneath it, and the lack of any bud in the axil of the truly subtending leaf were sufficient evidence of the "fusion." The branch truly subtended by the tenth leaf was likewise raised (for a distance of 3·5 millimetres) in insertion above the leaf; it was a short sessile fruiting branch. Above this, all the branches were more or less supra-axillary, but there was no suppression of leaves on the relatively main axis (the apparent suppression being due to branch-displacement).

On Accessory Branch V similar "fusions" and displacements occurred, the lowest being that truly subtended by the fifth leaf.

Atriplex rosea 191. (Curves 4 *m*, 4 I–IV.)

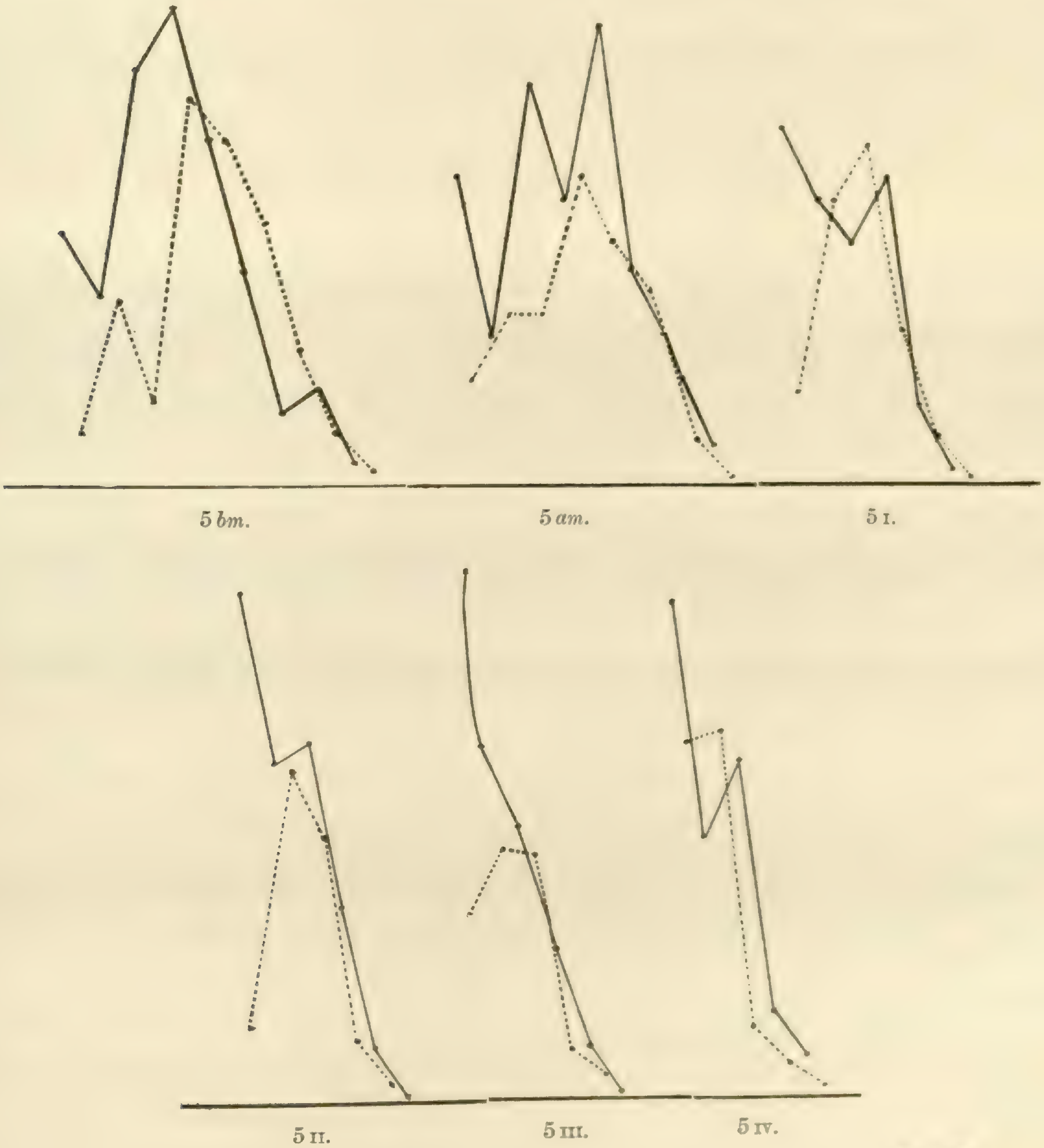


																	Approximate total length.
Secondary axis ..	*60*	2·5	*28·5*	11·5	*18·5*	11·5	*28*	17·5	*37*	35·5	*20*	21	*20*	12	*8*	8·5	340
Tertiary axis 2 ..	*65·5*	22·5	*54·5*	29·5	*51*	41·5	*52·5*	37·5	*38·5*	19·5	*7·5*	6·5	*4·5*	4·5	.	..	436
,, ,, 4 ..	*63*	36·5	*37·5*	28	*40·5*	19·5	*30*	14·5	*12·5*	10·5	*4·5*	..	..	..	..	..	297
,, ,, 5 ..	*67·5*	35	*58·5*	43·5	*57·5*	26	*45·5*	28	*12·5*	8·5	*4·5*	6·5	*3*	4	*1*	..	402
,, ,, 7 .	*50·5*	55·5	*46*	46	*3*	25·5	*13*	8·5									

The internode-subcurve of the secondary (relatively main) axis shows a double maximum and is intermediate between an ascending-descending and a purely descending

curve. The subcurves of the branches (*tertiary* axes), numbered from below upwards, show an admirable series of transitions to the purely descending curves, and that the changes in the internode- and displacement-subcurves are not synchronous. The irregularity of the internode-curves of these branches and the perfect consistency of the analysis of these into regular subcurves supplies most convincing evidence not only of the utility of the graphic method in elucidating morphological problems, but also of the truth of the view here put forward in regard to the true nature of the phyllotaxis of *Atriplex rosea* and Chenopodiaceæ in general. A similar, but even better, series is exhibited by specimen 187, about to be described, but concerning *quaternary* axes.

Atriplex rosea 187. (Curves 5 *am*, 5 I–IV, 5 *bm*.)



																			Approximate total length.
A. Tertiary axis	44	15	21	24·5	57	24·5	40·5	44	65·5	34·5	31	28	21·5	15·5	7	6	1	..	481
A. Quaternary axis 1..	51	13	41	41	34	48	44	22	11·5	7	2	1	..	..	..	..	..	..	316
A. „ „ 3..	72	11	48·5	47·5	51	38	27·5	9	8	2·5	1	..	..	..	..	..	..	..	316
A. „ „ 4..	75	27	50·5	36	38·5	35·5	21·5	7·25	7·5	3·5	·75	..	..	..	..	..	..	..	303
A. „ „ 5.	71	51	37·5	52·5	48	10	12	5	6	1·5									
A. „ „ 6..	70	46·5	53	46·5	43	6													
B. Tertiary axis......	35·5	7·5	27	26·5	58·5	12	67·5	54·5	49	49	30	37·5	10·5	19	13·5	7·5	3·25	2·25	511
B. Quaternary axis 3..	85	45	53	43·5	52·5	29·5	21	6·5	8·5	4	·75	..	..	..	..	..	..	..	349
B. „ „ 4..	66·5	1	67·5	32	34·5	25	18·5	13	5·5										
B. „ „ 6..	84·5																		
B. „ „ 8..	99																		

Measurements were made along two tertiary axes, A and B, which sprang from a secondary axis at nearly the same level. Measurements were also made along branches (quaternary axes) of these and are numbered from below upwards. Both the tertiary axes, and also the quaternary axes 1–4 on axis A and 1–3 on axis B, had completed their growth in length; the terminal part of Branch 6 on axis A had been broken off, so that the measurements cease abruptly (and its curves are not printed).

The internode-subcurve of the tertiary axis A is rather irregular in the early part of its course, but comparison with that of tertiary axis B indicates that the first descent is due to the curve being transitional towards a descending one. The second depression is probably due to the external circumstances, as we note similar depression taking place in the displacement-subcurve at the immediately preceding point in tertiary axis B. The subcurves of the quaternary axes on axis A show admirable gradual transitions to the descending form.

On several of the stems the branches were displaced upwards into a supra-axillary position. In the following skeletal sketch of these displacements, the number of each leaf is given first in Roman numerals and is followed by the number in ordinary type denoting the number of millimetres of upward displacement.

Tertiary axis A: IX, 7; XI, x; XII, 5; XIII, 3; XIV, 3. *Tertiary axis* B: XIII, 5·5; XIV, 4·5 (obliquely above the leaf); XV, 2·75 (obliquely above the leaf).

Quaternary axes:—Third branch on A: VI, 29 (line of fusion very clear). Fourth branch on A: IV, 3·5 (line of fusion very clear). Third branch on B: VI, 8 (line of fusion very clear). Fourth branch on B: VII, 11·5; VIII, x.

Erect Variety of Atriplex rosea.

Observations were made upon four specimens (Er^1, Er^2, Er^3, Er^4) of the erect variety of this species. and upon one specimen (I 28) that appeared to be transitional between the erect and the prostrate form. Between the two extreme forms several differences as regards mode of growth are revealed.

In the *erect variety* :—

(1) The main axis, at least at first, grows out more strongly in comparison with its branches; this would be anticipated, since it grows erect and has to raise aloft and carry the branches.

(2) The development of the branches at the base of the plant is much weaker. In the specimens examined no branches were emitted from the axils of the cotyledons; those emitted from the axils of the lowest two foliage-leaves were weaker than the immediately succeeding pair; sometimes the lowest two foliage-leaves subtended buds, though there were already branches in the axils of the succeeding pairs of leaves.

In the *transitional form* the branches at the base seemed likewise to be intermediate in their behaviour. Weak branches sprang from the axils of the cotyledons; a weak branch was emitted from the axil of the lowest foliage-leaf, and a stronger one from the other leaf of the first pair, but the branches emitted from the axils of the next pair of leaves were no stronger than the latter.

(3) The internode-curves and the subcurves are less regular than in the case of most of the specimens of the prostrate variety. It is possible that this greater irregularity is due to greater variation in the surroundings on the sloping sand, but it is also conceivable that the erect form is more unstable either because it has not yet reached the prostrate stage or has recently acquired its erect habit. The erect habit is certainly not due to the direct action of the environment, as both varieties are to be found growing side by side on the sand immediately at the foot of sand-dunes; though it is quite possible that the greater length of the early internodes of the erect form may result from the greater shade of the habitat.

(4) The internode-curves are clearly compounded of two subcurves. (The curves are not printed.)

Atriplex rosea Er^1.

																	Whole length.
Main stem ..	*8*	2	*19·5*	1	*29*	5·5	*35*	7	*38·5*	20	*22·5*	17·5	*12*	3	*5*	Flower cluster.	230
{ Branch III ..	*14*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	19
{ „ III′ ..	*8*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10
{ „ IV ..	*20*	1·5	*8*	1·5	.	..	..	..	..	..	..	..	..	..	..	..	35
{ „ IV′ ..	*17*	0	*10*	2·5	..	..	..	..	..	..	..	..	..	..	..	..	35
„ V ..	Not measured.																
„ V′ ..	*22*	7	*9*	4	..	..	..	..	..	..	..	..	..	..	..	..	45

Atriplex rosea Er^2 *and* Er^3.

														Whole length.
Er^2, Main stem..	*22*	2	*30*	2	*23*	22	*63*	12	*50*	27	*25*	10	Bud.	300
Er^3, Main stem..	*24·5*	0	*19·5*	3	*30*	9·5	*28*	21	*22·5*	13	*7*	10	Fruits.	150

In both plants Er^2 and Er^3 the cotyledons subtended buds; the first pair of foliage-leaves subtended minute branches, the second pair of leaves subtended longer branches. In plant Er^3 the third pair of leaves subtended still longer branches, and the fourth pair of leaves subtended the longest branches.

Atriplex rosea Er^4.

																	Whole length.
Main stem ..	*4*	1	*5*	1	*13*	4	*25·5*	2	*35*	8	*32*	8·5	*19*	2·5	*4*	Bud.	170
{ Branch II ..	*15*	0	*13·5*	..	..	..	..	..	..	..	..	..	..	..	..	..	39
{ „ II′ ..	*15*	0	*12*	..	..	..	..	..	..	..	..	..	..	..	..	..	35
{ „ III ..	*25*	0	*20*	7	*13·5*	7	10	Bud.	..	..	..	..	..	..	..	..	85
{ „ III′ ..	*19*	2·5	*19*	3·5	*12*	3·5	7	Bud.	..	..	..	..	..	..	..	..	65

Atriplex rosea I 28.

															Whole length.
Main stem	*21·5*	3	*19*	5	*14*	16·5	*23·5*	5·5	*45*	7	*38·5*	21	*14·5*	8·5	..
I and I′	..	..	..	..	..	..	..	..	..	..	..	..	..	..	22
{ Branch II	*28·5*	2·5	*14·5*	5	..	..	..	..	..	..	..	..	..	..	55
{ „ II′....	*37*	1	*28·5*	7·5	*17·5*	3·5	*12*	6	..	..		..	..	..	120
{ 3rd „ III ..	*42*	1·5	*22·5*	6·5	*9*	7·5	*6*	..	..	..	..	..	..	..	100
{ 4th „ III′ ..	*51*	1	*31*	11	*10*	9·5	6·5	..	..	..	..	..	..	..	120
{ „ IV ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	80
{ „ IV′ ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	65
{ „ V....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	55
{ „ V′....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	55

This particular specimen supplied a special proof of the utility of the graphic method. It was one of the first specimens that I measured, and at the time I was unaware of the fusions taking place between branches and main axis in the inflorescence region. My

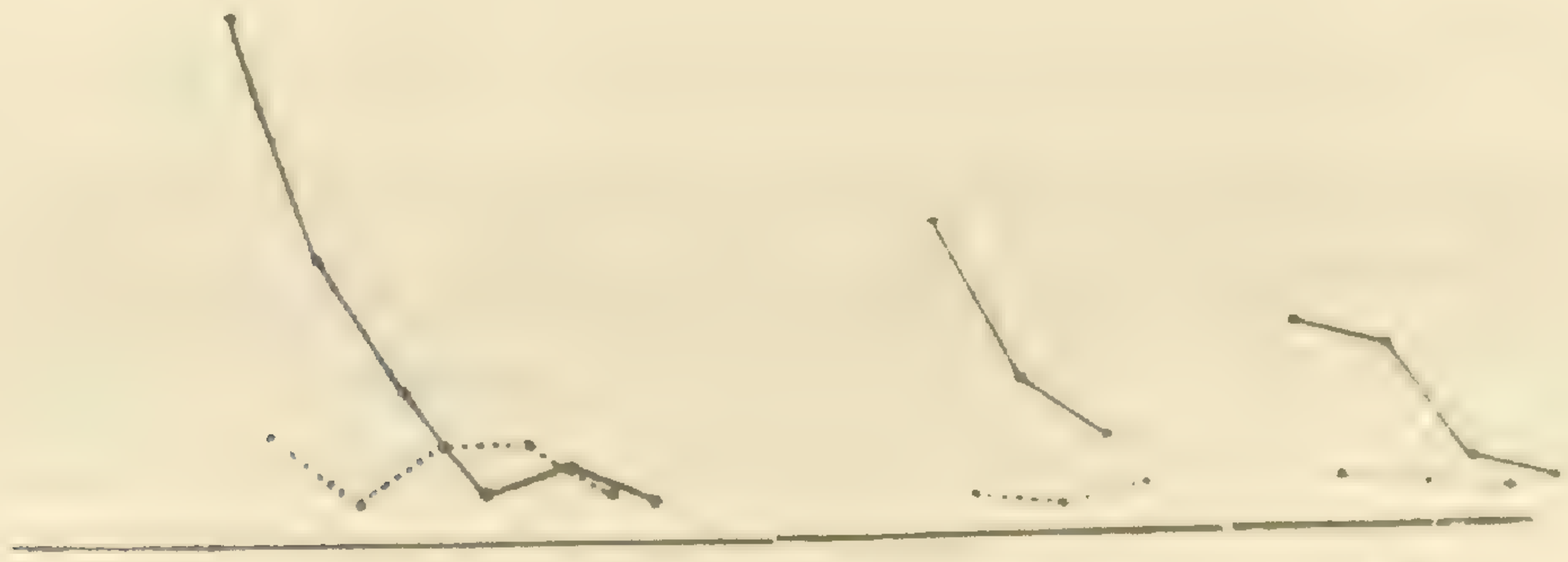
last six measurements on the main axis originally were *38·5*, 21, *6*, 8·5, *4*, 4·5. The resultant curve differed so entirely from those of specimens previously measured that I examined the axis in this region. I found that the measurement *6* was from a leaf which had no axillary bud to the insertion of a branch which apparently had no subtending leaf. Thus the branch was raised above the true leaf-axil, and the true measurement of the internode was 6+8·5=*14·5*. A similar raising of the branch above the axil of the next higher leaf had also occurred, so that the true displacement-measure was 4+4·5=8·5. These corrections regularized the subcurves and incidentally demonstrated the existence of "fusions" between branches and main axis.

Salsola Kali. (Curves 6 *m*, 6 I–III, 7 *m*, 7 I–V.)

Two specimens (Plants 8 and 10) were measured by Mr. A. Deane. The branches emitted at the cotyledonary node are termed cotyledonary branches; the branch in the axil of the first foliage-leaf is Branch I and so forth.

6 *m*. 6 I. 6 II. 6 III.

7 *m*. 7 I. 7 I'. 7 II.



7 III. 7 IV. 7 V.

PLANT 8. (Curves 6 *m*, 6 I–III).

																			Length of terminal part
Main stem	*10·5*	0	*8·5*	2·75	*8·5*	4·5	*10·5*	8·5	*7·5*	6·5	*7*	2·75	*7·25*	..	..	..	..	..	18
Cotyled. branch ..	*25*	4·75	*21*	5	*14·25*	10	*7·5*	9	*5·5*	9	*5*	2·5	*6*	4·5	*5·75*	4·25	*4·5*		
Branch 2	*23*	5	*19·5*	7	*9·5*	11	*8·25*	4	*7·5*	6·5	*3*	2·5	*3·5*	3	*5·5*	..	..	..	13·5
„ 3	*18*	5	*22*	11·5	*7·5*	12·5	*7*	6·5	*8*	6·5	*5·5*	4	*7·5*	3	*4·5*	6·25	*2·25*	3·5	29·5

PLANT 10. (Curves 7 *m*–7 II.)

Main stem	*4·5*	4·5	*6·25*	3·75	*8*	3·75	*3*	2·5	*2·5*	3·5	..	..	..	..	..	..	..	..	12
{ Cotyl. branch (*a*)..	*16·5*	3	*8*	·5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	12
{ „ „ (*b*)..	*19·25*	4	*6*	..	..	.	..	..	..	..	..	..	..	..	..	..	..	..	6·5
{ Branch 2	*26·5*	6·5	*14·5*	4·25	*6·5*	4·75	*3·75*	3	..	..	..	..	..	..	..	..	..	..	17
{ „ 3	*30·5*	6·5	*16·5*	2·25	*8·5*	5·75	*3*	5·75	*4·5*	2·75	*2·5*	..	..	..	..	..	..	..	13·5
„ 4	*18*	2·5	*9*	1·75	*5·5*	2·75	..	..	..	..	..	..	..	..	..	..	..	..	14
„ 5	*12*	2·75	*10·75*	2·5	*4*	2·25	*2·75*												

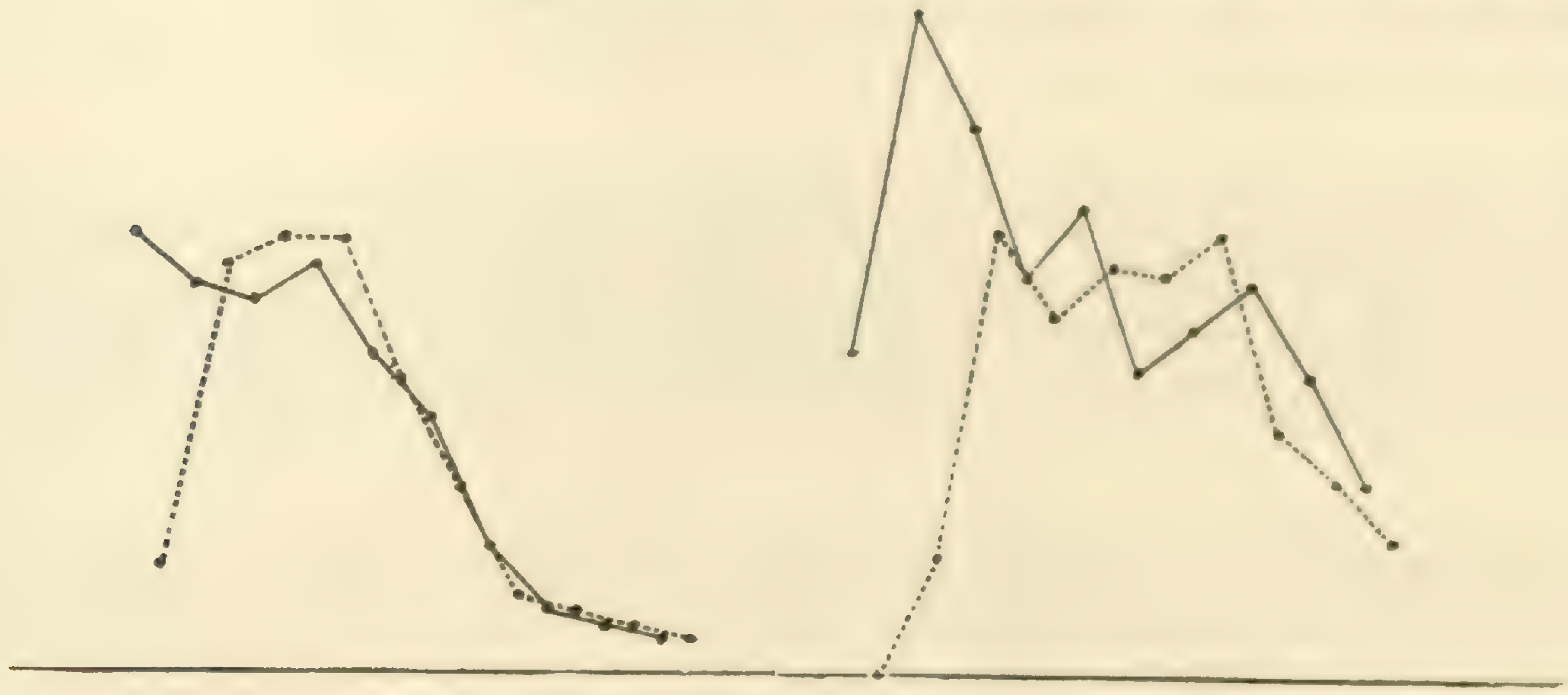
The measurements establish the existence of two subcurves in the internode-curve, though the two specimens show differences in detail and irregularities. The internode-subcurve of the main stem of one specimen and the corresponding displacement-subcurve of the other specimen are of the ascending-descending form, but the other two sub-curves of these main stems though not irregular are not of this form; but similar deviations from the type occur in individual plants of *Atriplex rosea*. The internode-subcurves of the branches of both plants are largely of the descending type (possibly in part because of the young condition of some of the branches). The displacement-subcurves of *Salsola* 8 are of the ascending-descending form; those of *Salsola* 10 largely of the descending form (possibly partly because of immaturity of the internodes measured). The irregularities in the subcurves may be due to external variations or to peculiar correlations (see my previous paper).

CHENOPODIUM BONUS-HENRICUS. (Curves 8, 9.)

Measurements were made (by Mr. A. Deane) along the main stems of two specimens, numbers 32 and 34. The terminal part of the latter was broken off. Records as to the exact height up the stem at which measurements commenced are lacking, but probably this was lower in plant 34. The following are the measurements made :—

Plant.																				
32 ..	*36·5*	8·5	*32·5*	34	*31·5*	36·5	*34·5*	*36·5*	*27*	24·5	*21·5*	15·5	*10·5*	6·5	*5*	4·75	*4*	4	*3*	3
34 ..	*27·5*	0	*57*	10	*47·5*	38	*34·25*	*31*	*40·5*	35	*26·5*	34·25	*30*	38	*34*	21	*25·75*	17	*16·5*	12

The curves clearly are composed of two subcurves, those of specimen 32 being regular and those of specimen 34 irregular. In the latter, commencing at the third ordinate the internode-segment and the succeeding displacement-segment form pairs that show



8. 9.

deviations from regularity always in the same sense, as if they had been abnormally shortened or lengthened by external circumstances.

I also made measurements of two main stems of a species of *Chenopodium*, whose specific name I omitted to record. For this reason, I omit details of the measurements, which gave internode-curves capable of analysis into normal internode-subcurves disturbed by irregularities, and very regular displacement-subcurves of the ascending-descending type.

CARYOPHYLLACEÆ.

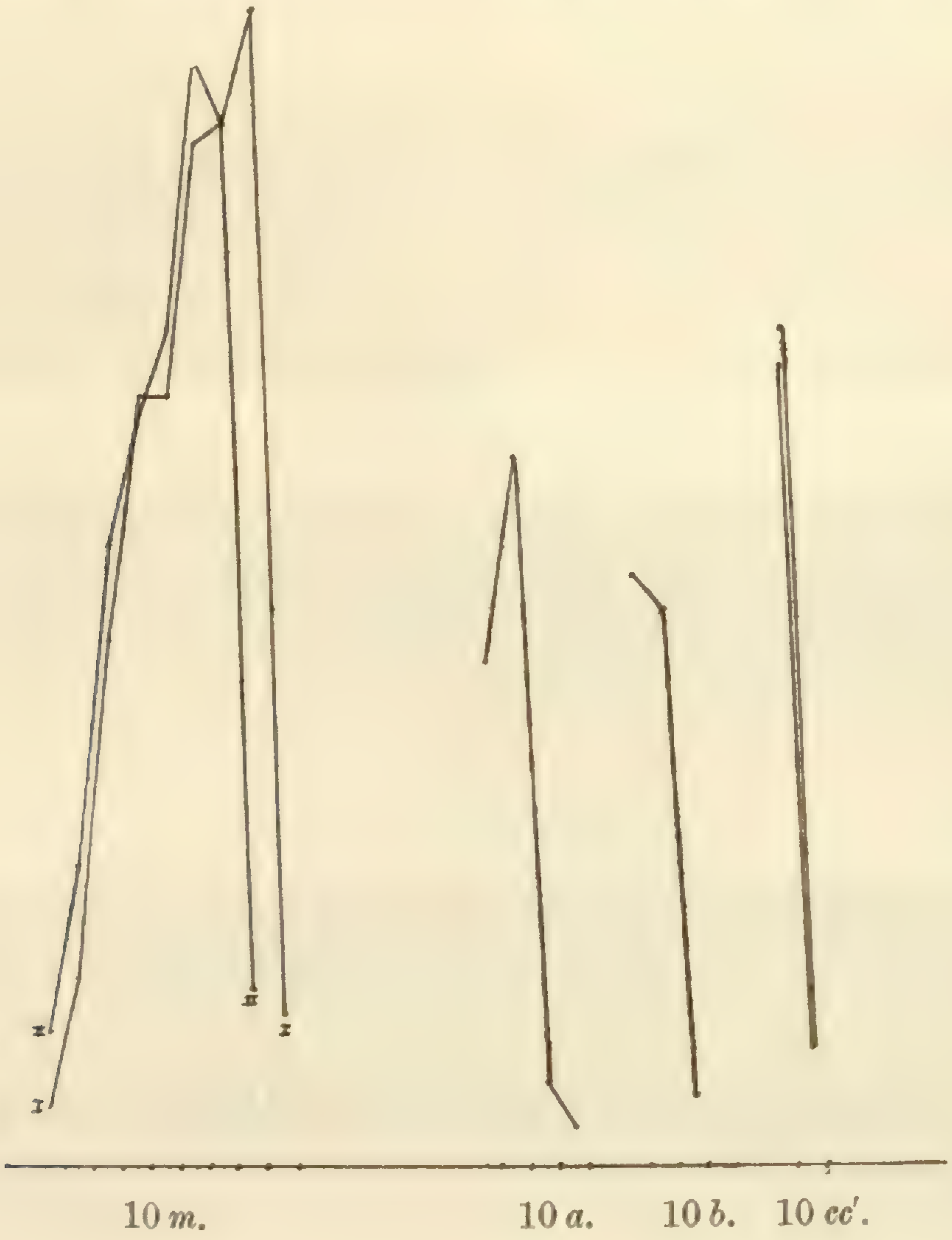
This family, almost without exception (e. g. *Pychnophyllum*), shows cyclic phyllotaxis. And in accordance with this the genera *Lychnis* and *Stellaria* show internode-curves that are typical and regular. This fact gains interest when it is remembered that in all the Caryophyllaceæ so far investigated the inception of the two leaves at a node is described as being not simultaneous. The statement is that in the vegetative region the leaf subtending the strengthened branch arises earlier than its fellow, whereas in the floral region the reverse is true. This peculiar behaviour is not in the least reflected in the internode-curves. If the opposite type of phyllotaxis is the primitive one in the Centrospermæ, then this difference in the time of development of the two leaves at the caryophyllaceous nodes would seem to foreshadow the more advanced type of the Chenopodiaceæ, where the two leaves become separated. Even if the primitive phyllotaxis of the Centrospermæ were spiral, the leaf-arrangement of the Chenopodiaceæ equally shows a transition to that of the Caryophyllaceæ. In any case the leaf-arrangement of the Chenopodiaceæ seems to shed light upon the hitherto incomprehensible peculiarity of the successional development of the leaves in the Caryophyllaceæ.

The shoots of *Cerastium arvense* examined did not show such regularity in their internode-curves; yet the irregularities were not of the repeated, sudden, and extensive nature that indicates leaf-displacement.

LYCHNIS DIURNA. (Curves 10 *m*, 10 *a*, *b*, *cc′*.)

The specimen examined had a number of long shoots springing from the root-stock, their basal internodes being prostrate and the higher ones (above the fourth) erect. Of these shoots two, I and II, were measured; these had practically concluded their growth in length, as each ended in a fruit; the last measurement is up to the highest pair of leaves.

Shoot II bore branches at the fifth to seventh nodes (reckoning the lowest node as the first); these branches are termed *a*, *b*, *c*, and *c′* respectively; *c* and *c′* both sprang from the seventh node. Branches *c* and *c′* ended in fruits; *b* ended in a young fruit and *a* in an open flower. The final measurement was to the uppermost pair of leaves.



The following measurements were made (as the leaves were opposite at all the nodes, the zero-measurements are omitted throughout):—

										Total.
Shoot I ..	10·5	33	92	134	134	178	181·5	201	26·5	
,, II ..	23·5	52·5	108	131	145·5	192·5	182	31		
Branch *a* ..	87	123	14·5	7	..	..	..	..	..	231·5
,, *b* ..	102	96·5	12	..	..	..	..	..	..	210·5
,, *c* ..	138	20·5	..	..	..	..	..	..	..	158·5
,, *c′* ..	145	20·5	..	..	..	..	..	..	..	165·5

The internode-curves of Shoots I and II are obviously normal, regular, and very similar.

The internode-curves of the branches *a–c′* show the change from the normal (ascending-descending) type to the purely descending form.

Lychnis dioica.

Two specimens of this double species were measured by Mr. A. Deane, but as I do not know whether the plant was *Lychnis diurna* or *L. vespertina,* I merely give the statistics (without supplying the curves), in order to show the regular nature of the caryophyllaceous internode-curve.

An erect shoot ending in a flower was measured up to the topmost pair of leaves. The following results were obtained :—20, 117·5, 112, 90, 67·5, 60, 15.

The internode-curve is regular and normal.

The relatively main axis of another specimen had been destroyed above a certain node, and two branches, I and I *a*, springing from this node had functionally replaced it. The question was as to how far the internode-curves of these would be modified. The result showed that in their proximal regions they simulated an erect relatively main axis by having short internodes and producing an ascending internode-curve ; but in their distal parts there was no decrease in length of the internodes, so that the internode-curves were purely ascending ones of regularity undisturbed save at one point on Branch I. Both branches ended in fruits :—

								Total.
I	4·5	8	20	33	53	48	62	228·5
I *a*	4·5	19	39·5	47·5	56·5	. .	. .	167

The statistics suggest that these branches did not grow out until after the injury to the parent axis, and show that the strengthened branch still maintained its predominance.

Stellaria media. (Curve 11.)

One main stem terminating in a flower was measured, the following being the results:—24, 30·5, 35·5, 42, 47.

(The zero-measurements between the two leaves at each node are omitted.)

11.

The internode-curve is a purely ascending one, and thus deviates from the typical internode-curve of a main stem. Its regularity is such that, within the limits of possible accuracy of observation, the curve assumes the form of a straight line.

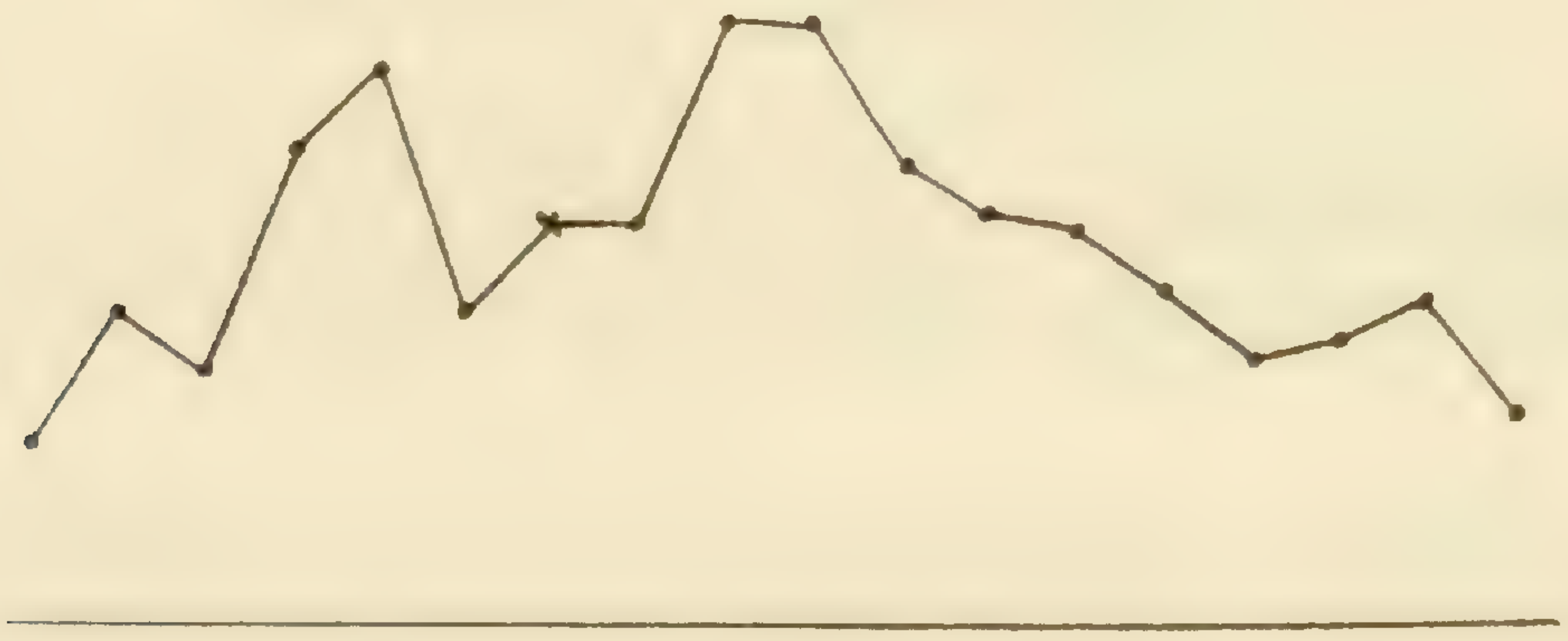
CERASTIUM ARVENSE. (Curves 12, 13.)

This plant is much ramified and is largely constituted of lanky thin shoots which have long, horizontal, monopodial, subterranean parts whose ends emerge from the soil and continue as elongated superterranean shoots.

Both the branches measured arose as branches of a subterranean shoot, and their proximal parts were underground and emitted roots at the nodes, while their more distal portions were above ground. In each case the measurements commenced at the basal internode of the branch.

In the subjoined series of numbers a × is placed after the number representing the measurement of the highest subterranean internode, and in the curves a × is placed at the top of the ordinate representing these internodes. The specimens were collected in November, yet the highest measured internodes had not attained their full lengths and the shoots terminated in active buds.

12.



13.

Branch I:—10, 12·5, 23·5, 18, 18·5, 12·5, 9, 8, 11·5, 14, 20, 20·5, 23, 25·5×, 22·5, 20, 26, 26, 23, 25, 24·25, 22, 21·5, 20, 18·5, 19, 20, 16, 15·5, 13·5, followed by young internodes.

Branch II:—10·25, 17·5, 14·5, 27·5, 32, 17·5, 23×, 23·25, 34, 33·75, 26, 23·5, 22·5, 18·5, 15, 16, 18·25, 12, followed by young internodes.

Both internode-curves show an initial ascent, succeeded in order by a descent, an ascent, and a final descent. These general features are more or less disturbed by minor sudden rises and falls. To what extent the irregularities are due to external circumstances it is impossible to say. It is worthy of note that the first maximum and the first two minima occur in the subterranean part, so that etiolation does not overpower other influences that aid in determining the internode-lengths. The ascents and descents in the curves are not of the sudden and repeated kind characteristic of leaf-displacements (all the leaves were in opposite pairs), but are generally of a more gradual type, suggesting partly innate characters and partly characters induced by temporary change in environment.

AIZOACEÆ.

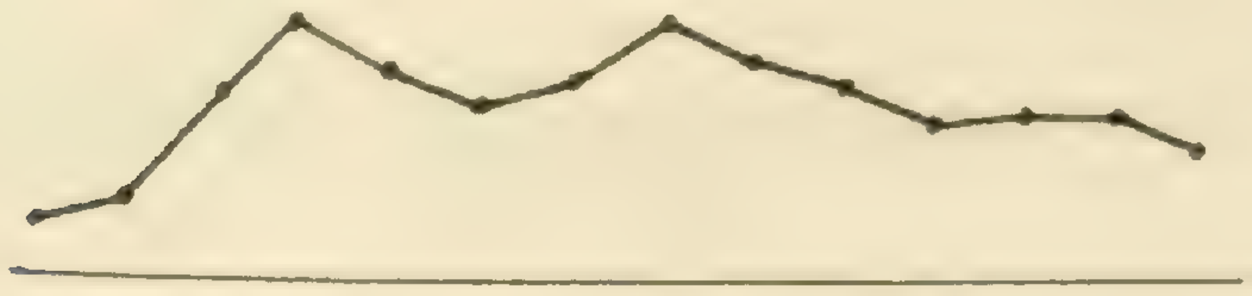
The genus *Mesembryanthemum* includes opposite- and alternate-leaved types. The two species that I examined belonged to the opposite-leaved type. The curves, if not quite regular, showed irregularities of only minor extent and gradual form, such as might easily be due to slight variations in the surroundings or to the different ages of the internodes.

MESEMBRYANTHEMUM ECHINATUM. (Curves 14 I–II.)

Two branches inserted at neighbouring nodes of the same relatively main axis were measured from the base up to the terminal active bud. The following are the measurements obtained:—

Branch I:—3, 4·25, 10, 14, 11·5, 9·5, 11, 14·5, 12, 10·5, 8·5, 9, 9, 7·25, bud.

Branch II:—3, 2·5, 7, 13, 12, 12, 10, 12·5, 14, 9·5, 6·5, 8, 8, shorter internode and bud.



14 I.

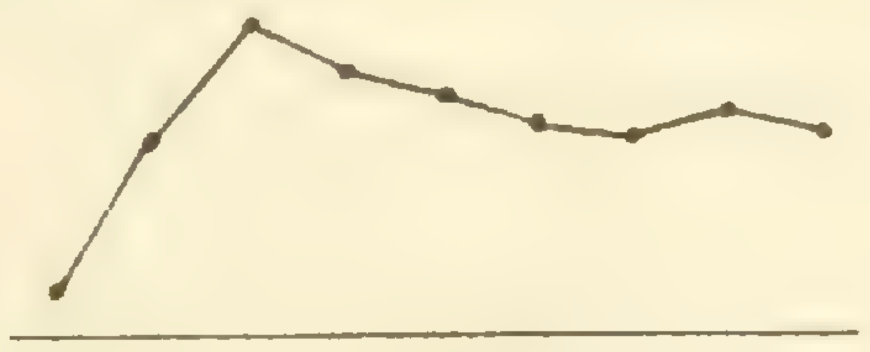
14 II.

Both the internode-curves show an initial rise, followed by a fall, a rise, fall, rise, fall. The final descent, in any case, is due to the immaturity of the internodes.

MESEMBRYANTHEMUM FILAMENTOSUM. (Curve 15.)

A seedling of this species was uprooted, and the measurements, commencing at the cotyledonary node, were as follow:—2·5, 10·5, 16, 14, 12·5, 11, 10·5, 12, 10·5.

In this comparatively young and actively growing plant it was not possible to tell the



15.

extent to which the internodes had attained their full length. The internode-curve is regular and normal except for the final slight rise.

AMARANTACEÆ.

This family includes both alternate- and opposite-leaved types, and species of both kinds were measured. The alternate-leaved plants belonged to the genus *Amaranthus*, the opposite-leaved plants to the genera *Gomphrena* and *Froelichia*.

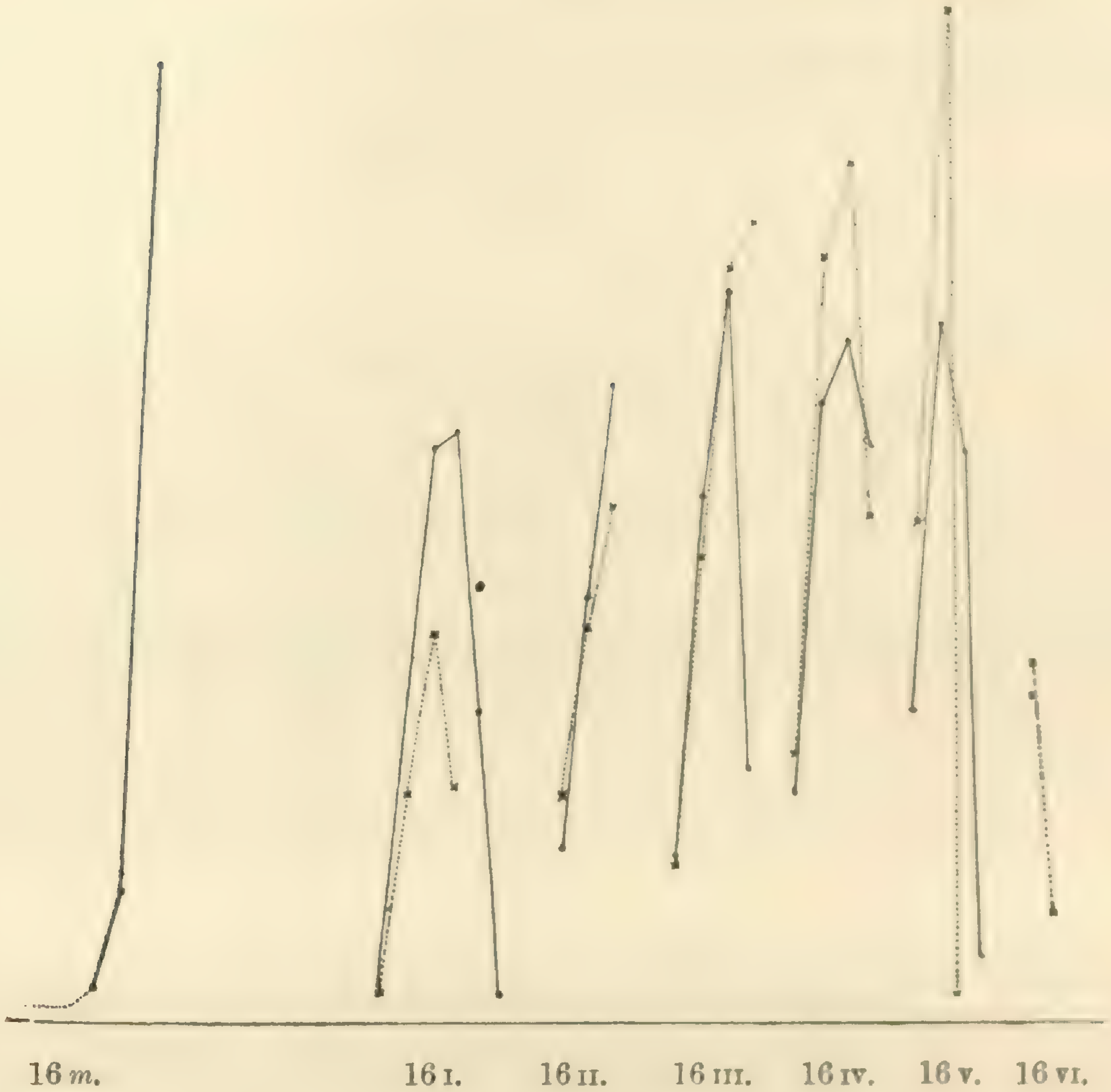
The species with cyclic phyllotaxis exhibited regular internode-curves, which strongly contrasted with the extremely irregular internode-curves of the alternate-leaved species. The sudden and frequent irregularities of the latter clearly indicated displacements of the leaves, yet analysis of the internode-curves did not yield two regular subcurves. Consequently it is impossible to decide whether the plants signify a transitional condition from cyclic phyllotaxis with two or more leaves at a node towards acyclic phyllotaxis, or the reverse. At least the facts denote leaf-displacements due to inherent characters. Yet in the alternate-leaved types the primitive opposite phyllotaxis is suggested by the divergences of the leaves at the base of the main stem, which agreed exactly or approximately with those of decussate phyllotaxis.

In this family the phenomenon of fasciation in connexion with the terminal inflorescence is closely akin to fusion of branches with the main axis in Phytolaccaceæ and Chenopodiaceæ. In all cases it is probably to be attributed to precocity of outgrowth of branches.

GOMPHRENA DECUMBENS. (Curves 16 *m*, 16 I–VI.)

This annual, opposite-leaved plant was uprooted. From the base of the main stem sprang a number of procumbent branches and accessory branches, so that it was not easy to see instantly which was the main axis; and exact measurements of the lower internodes of this were out of the question.

The cotyledonary scars subtended buds. The branches in the axils of the first pair of foliage-leaves are termed Branches I and I′, those in the axils of the second pair of leaves Branches II and II′, and so forth.

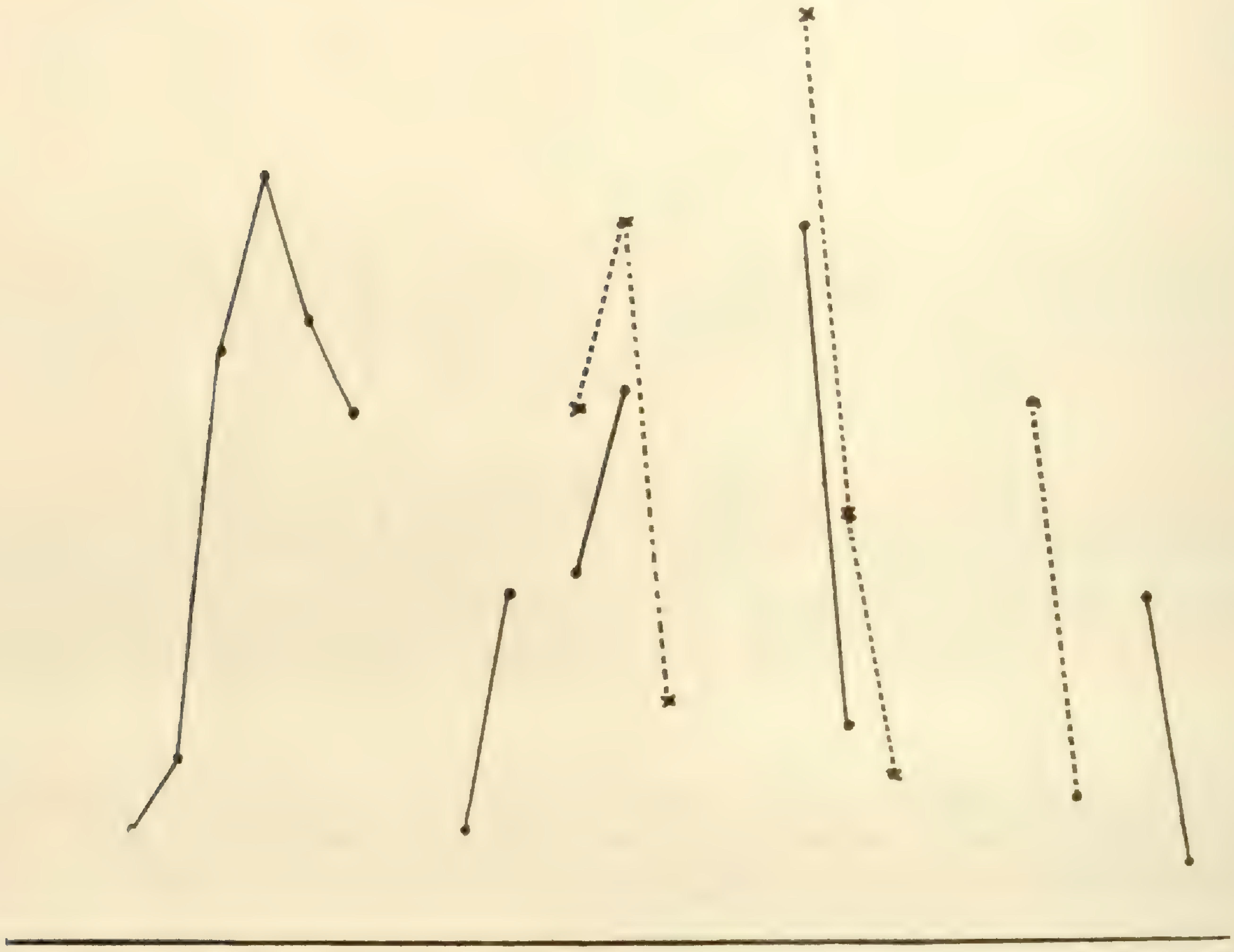


The following are the measurements made (zero-measurements representing the distance apart of the two leaves at each node are omitted) :—

Main axis....	? (3 *circa*)	? (3 *circa*)	? (3 *circa*)	7·25	26·5	194	Ending in a terminal infructescence.
Branch I	6	46·5	79	..	..	..	Ending in growing bud.
" I′ ..	8	53	117	120	63·5	6	Ending in open terminal inflorescence.
" II ..	35·5	86·5	130	..	..	..	Broken off at end.
" II′ ..	46	80·5	105	..	..	..	" "
" III ..	33·5	107·5	149·5	52 (*circa*)	..	..	Ending in open inflorescence.
" III′ ..	32·5	95·5	154·5	164	..	..	" " "
" IV ..	47·5	126·5	140	119	..	..	" " "
" IV′ ..	55	157·5	176·5	104	..	..	" " "
" V	64	143·5	117 (*circa*)	13·5	..	..	" " "
" V′ ..	102·5	208	6 (*circa*)	..	..	..	Ending in old inflorescence.
" VI ..	67	..	..	..	..	..	" " "
" VI′ ..	74	22·5	..	..	..	..	" " "

The regularity of the internode-curves and the orderly manner in which the successive branches change their longitudinal symmetry are especially obvious if comparison is made between the strengthened and weakened branches respectively at the successive nodes.

GOMPHRENA GLOBOSA. (Curves 17 *m*–17 V.)



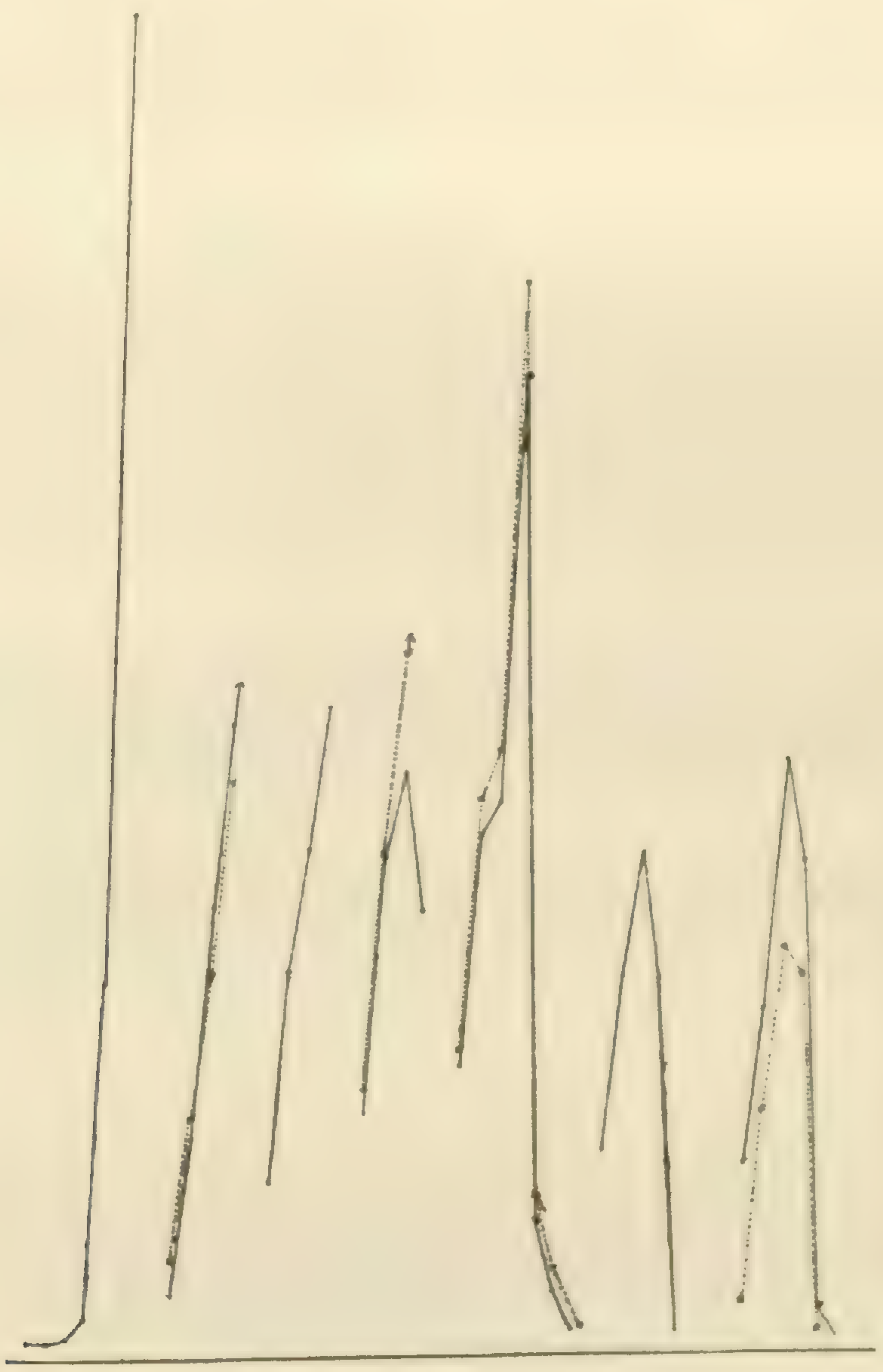
							Remarks.
Main axis....	12·5	20	64·5	85	68·5	58·5	The last measurement was to two bracts, above which succeeded the sessile terminal inflorescence and a lateral sessile inflorescence.
Branch I	..	..	..	..	..	..	Young and small.
" I'	12·5	38	..	..	..	..	Ended in a young internode and an active bud.
" II ..	40·5	60·5	..	..	..	..	" " "
" II' ..	59	79·5	26·5 (young)	..	..	..	" " "
" III ..	78·5	23·5 (young)	..	..	..	..	" " "
" III' ..	102	47	18·5	..	..	..	" " "
" IV ..	..	..	..	..	..	..	Young.
" IV' ..	59·5	15·5 (young)	..	..	..	..	Ending in young internode and active bud.
" V	38·5	8	..	..	..	..	Capped by two sessile leaves, then two bracts, and an open terminal inflorescence.
" V' ..	20	..	..	..	..	..	Ending in young inflorescence (four leaves and two bracts visible).
" VI ..	8	..	..	..	..	..	Ending in leaves and young open inflorescence.
" VI' ..	28	..	..	..	..	..	" " "

This annual opposite-leaved plant was uprooted, and measurements were commenced at the lowest distinct pair of leaf-scars (of the cotyledons?). These leaves and the branches they subtend are termed I and I′, similarly the branches emitted from the second node are termed II and II′, and so forth.

As the leaves at all the nodes were opposite, the zero-measurements representing the longitudinal distance from one leaf to the other at a node have been omitted from the Table on p. 290. The internode-curves, so far as the limited number of internodes present allow one to see, are regular.

Froelichia gracilis. (Curves 18 *m*, 18 I–VI.)

This opposite-leaved annual herb was uprooted, and measurements began at the lowest visible leaf-scars, which subtended Branches I and I′. The remaining branches are



18 *m*. 18 I. 18 II. 18 III. 18 IV. 18 V. 18 VI.

numbered according to the nodes (as in the case of *Gomphrena*). (In the subjoined Table the × denotes the commencement of the terminal inflorescence, as all the leaves above this point subtended only inflorescences.)

Main axis....	4·5 (*circa*)	4·5 (*circa*)	5 (*circa*)	10	96·5	346	?	End broken off.
Branch I	16·5	57·5	112	165	?	..	..	Ends in a long internode broken off at a length of 280 mm.
„ I′....	26	62	99	148	?	..	..	Ends in a long broken internode.
„ II ..	45	100	130·5	169	?	..	..	Ends in broken and decayed internode.
„ III ..	62·5	129	151	115	?	..	..	„ „ „
„ III′ ..	69	130	182·5	?	..	..	..	Ends in decaying internode broken at length of 180 mm.
„ IV ..	75	134·5	143	253×	35	16·5	7	Ending in short internode capped by terminal inflorescence.
„ IV′ ..	79	144	158	278×	42	22·5	7·5	
„ V....	53	98·5	130	97·5×	6	..	..	Ending in terminal inflorescence.
„ VI ..	49·5	89·5	154·5	127·5×	12	4	..	„ „ „
„ VI′ ..	13·5	63·5	105	98×	6	..	..	„ „ „

All the parts measured had attained their mature length.

The regularity of the internode-curves is striking, as is the agreement between those of the pairs I and I′, IV and IV′. The basal branches seem to have ascending internode-curves, but this is due to the fact that the terminal parts were decayed and had fallen. None of the branches show the descending form of internode-curve, yet Branches I to IV′ display the extremely regular gradual increase in length of the basal internode as the insertion of the branch rises.

Amaranthus retroflexus and A. polygonoides.

The internode-curves of these alternate-leaved species contrast excessively with those of the opposite-leaved Amarantaceæ. The main axes of both show very irregular internode-curves, suggesting displacement. At the commencement of the curve it can be analysed into two regular ascending subcurves, on the assumption that the primitive arrangement was cyclic, with two leaves at a node. But soon the internode-curve becomes irregular, and the subcurves produced by the same analysis are also irregular. In both cases the repeated maxima are alternately separated by three and five leaves; such a condition would be produced if the arrangement were primitively composed of nodes with alternately three and five leaves, and these had been relatively displaced, but the original internodes had still continued to be longer than the displacement-segments.

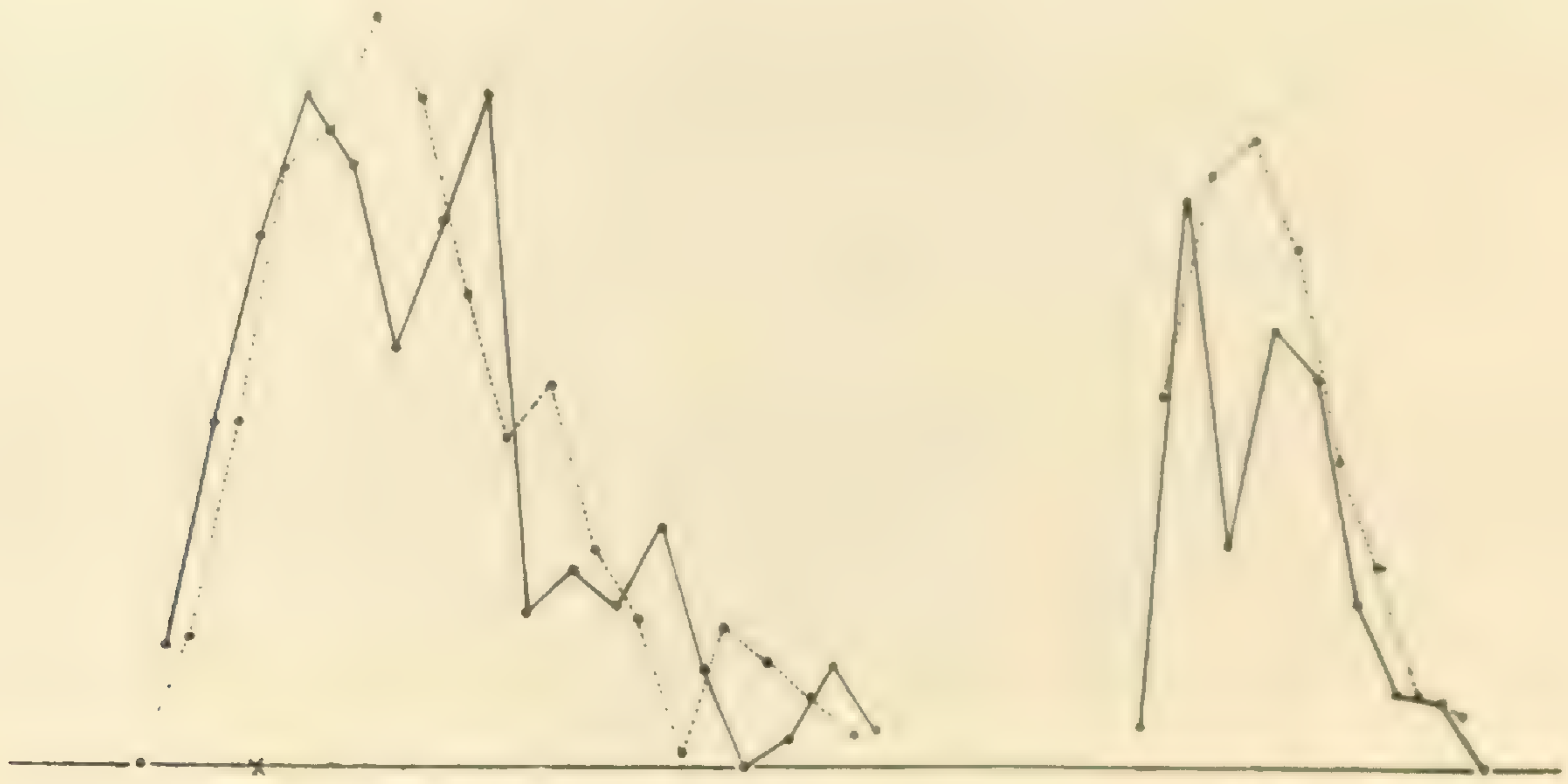
The measured branch of *A. retroflexus*, on the contrary, produced an internode-curve that analysed into two regular subcurves, disturbed only at one point in the case of the internode-subcurve.

Amaranthus retroflexus. (Curves 19 *m*, 19 *x*.)

This alternate-leaved annual plant was uprooted, and the measurements were commenced at the lowest indubitable leaf-scars, which were opposite and probably were

those of the lowest pair of foliage-leaves. The next two pairs of leaves were decussate, or approximately so, as regards divergence, though separated by a considerable length of stem. The following are the measurements made:—

0, *13*, 14 (*circa*), *38*, 38, *58*, 66, *74*, 70, *66*, 82·5, *46·5*, 73·5, *60*, 52, *74*, 36, *17*, 42, *21·5*, 24, *18*, 16, *26·5*, 1·5 (*circa*), *11*, 15·5, *0* (*circa*), 11·5, *3*, 7·5, *11*, 3·5, *4*.



Where the curve descends to zero the shoot is in the inflorescence region, and a phyllotaxis commences in which two subopposite leaves at a node decussate with a single leaf at the next node, as if at a number of alternate nodes one leaf in a decussate arrangement were suppressed. The measurements stopped at about the middle of the terminal compound inflorescence.

Branch x was inserted at the fifth node (marked by a × in the curve). Its successive measurements were:—

4, 42, *63*, 66, *25*, 70, *49*, 57·5, *43·5*, 34, *18*, 23, *8·5*, 8, *7·5*, 6, *0*.

The measurements ceased at the commencement of the compound inflorescence, where the bracts began an arrangement in decussating pairs of opposite or subopposite leaves, and rapidly dwindled from small foliage-leaves to small bracts.

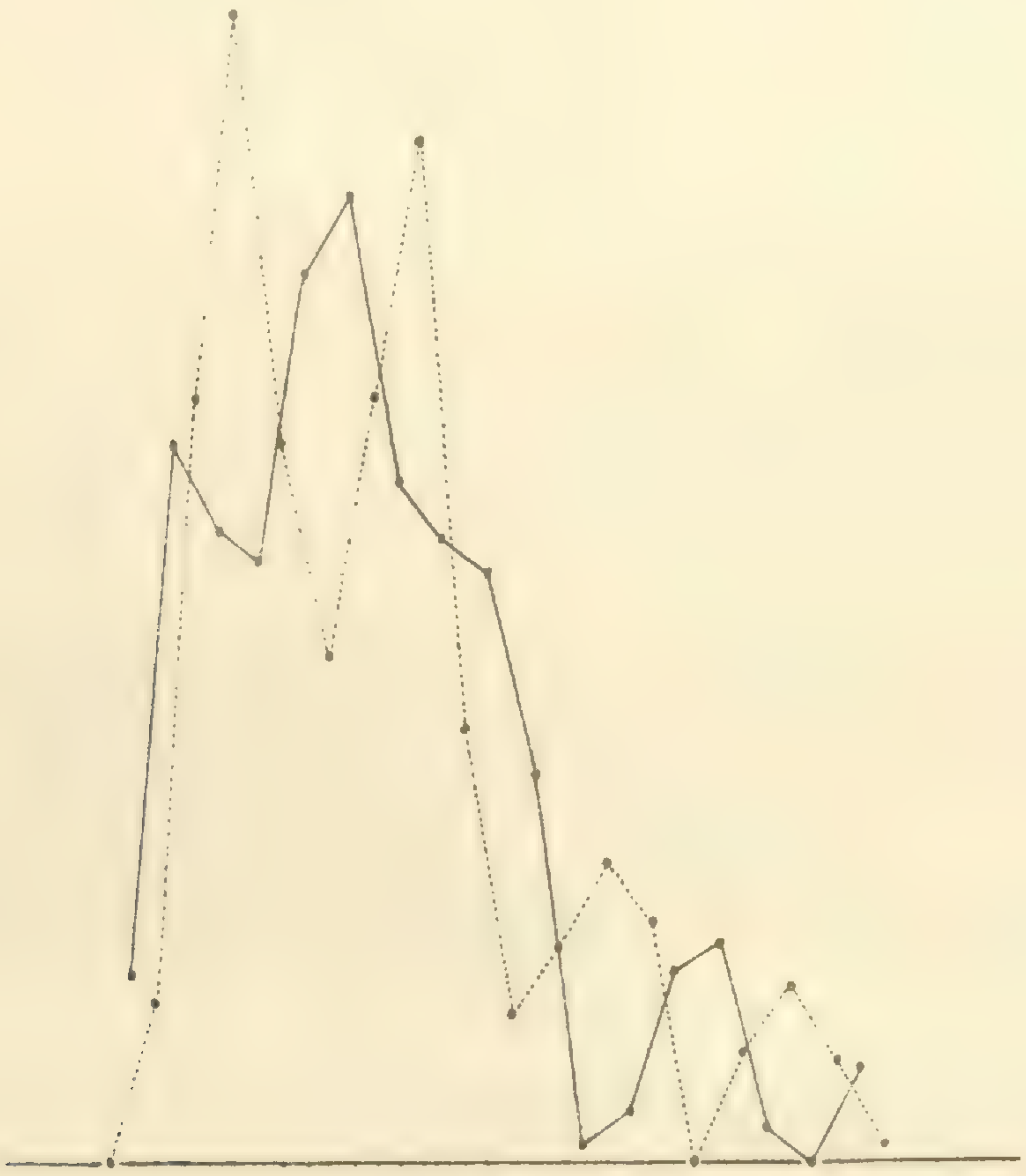
Amaranthus polygonoides. (Curve 20.)

This annual plant was uprooted, and measurements were begun at the lowest two scars which were opposite (and possibly represented the points of insertion of the cotyledons). The next pair of leaves were decussate in divergence, but separated by a considerable length of stem. The following are the measurements made:—

0, *20*, 17, *78*, 83, *68·5*, 125, *65·5*, 78, *97*, 54·5, *104·5*, 82·5, *74*, 110, *67·5*, 47, *64*, 16, *42*, 23·5, *2*, 32·5, *5·5*, 26·5, *21*, 0, *23·5*, 12, *3·5*, 19, *0*, 11, *10*, 2.

Where the curve first sinks to zero the shoot is wholly reproductive—that is to say, it

is the terminal compound inflorescence—and the leaves begin to show signs of decussate or peculiar paired arrangements.



20.

PHYTOLACCACEÆ.

The Phytolaccaceæ apparently include only alternate-leaved forms. Despite of the fixed nature of the acyclic phyllotaxis the internode-curves are very irregular, and there is no doubt that analysis into two subcurves removes the irregularities entirely, or at least lessens them.

Analysis of the extremely irregular internode-curve into two regular subcurves may be noted in connexion with the main axis of *Phytolacca esculenta* I. (Curve 21) and the branches of *P. decandra* I. (Curve 23 I), *P. esculenta* II. (Curve 22 I). In the first branches of these two the depression in the middle of the displacement-subcurves is doubtless due to this curve being transitional between a normal (ascending-descending) one and a purely descending one.

Analysis of the extremely irregular internode-curves into two considerably less irregular subcurves is represented by the relatively main stem of *Phytolacca polyandra* (Curve 24) and Branch A of *Ercilla spicata* (Curve 25 I).

Thus the internode-curves of Phytolaccaceæ point clearly towards the view that the phyllotaxis of the ancestor was cyclic. In harmony with this stands the fact that at the base of the main stems of the species of *Phytolacca* examined the divergences of the leaves more or less perfectly conform with those of decussate phyllotaxis. But, as pointed out in my previous paper, this might represent a necessary mode of transition

from the opposite cotyledons to the alternate higher leaves, and might be equally found in truly alternate-leaved types.

PHYTOLACCA ESCULENTA I. (Curve 21.)

A specimen of the seedling plant of this perennial herb was uprooted in September. Above the tuberous tap-root at the base of the stem were two large opposite buds flanked by a smaller bud on each side and subtended by a single small bud. The large buds I assume to be those on the axils of the fallen cotyledons.

21.

Above these succeeded the decurrent bases of two fallen leaves, decussate in reference to the cotyledons, but not inserted at the same level. The distance from the cotyledons to the lower of these was 12·5 (*circa*), from the latter to the upper leaf 3 (*circa*). The succeeding two leaves were approximately decussate in reference to these, but not inserted at the same level; the interfoliar distances were 17·5 and 7·5 (*circa*) respectively. The next pair of leaves, though showing a decussate tendency, were clearly not separated by an angle of 180°; the interfoliar measurements were 24·5 and 23·5 respectively. In all the remaining leaves evidence of opposite phyllotaxis, as far as angular divergence is concerned, was lacking. The following comprise the complete series of measurements :—

0, *12·5*, 3, *17·5*, 7·5, *24·5*, 23·5, *37·5*, 54, *57·5*, 60·5, *77*, 54, *43*, 30·5, *27·5*, 24, *17·5*, 14.

Measurements were stopped at this point because the internodes above were young and incomplete in length, and a number of the later measurements given here undoubtedly represent immature internodes.

The resultant internode-curve is zigzag, but can be analysed into two very regular subcurves.

PHYTOLACCA ESCULENTA II. (Curves 22 *m*, 22 I–II.)

An erect shoot was removed close to the ground from a specimen more than one year old. The following measurements were made:—

54·5, 53·5, *65·5*, 80·5, *73*, 72·5, *71*, 75, *77*, 69, *70·5*, ×, 83.

The final measurement was up to the topmost leaf, above which the axis ended in an inflorescence whose axis was "fused" with a branch (Branch II) for a distance of 39 mm. The × denotes the point of insertion of Branch I.

22 *m*. 22 I. 22 II.

The measurements of Branch I were as follow:—

175, 53, *66·5*, 10, *55·5*, 30·5, *19*, 51·5.

The last measurement is to the topmost leaf, above which the terminal inflorescence was pushed aside and fused for a distance of 7 mm. with an axillary branch.

The measurements of Branch II were as follow:—

137, 46, *82*.

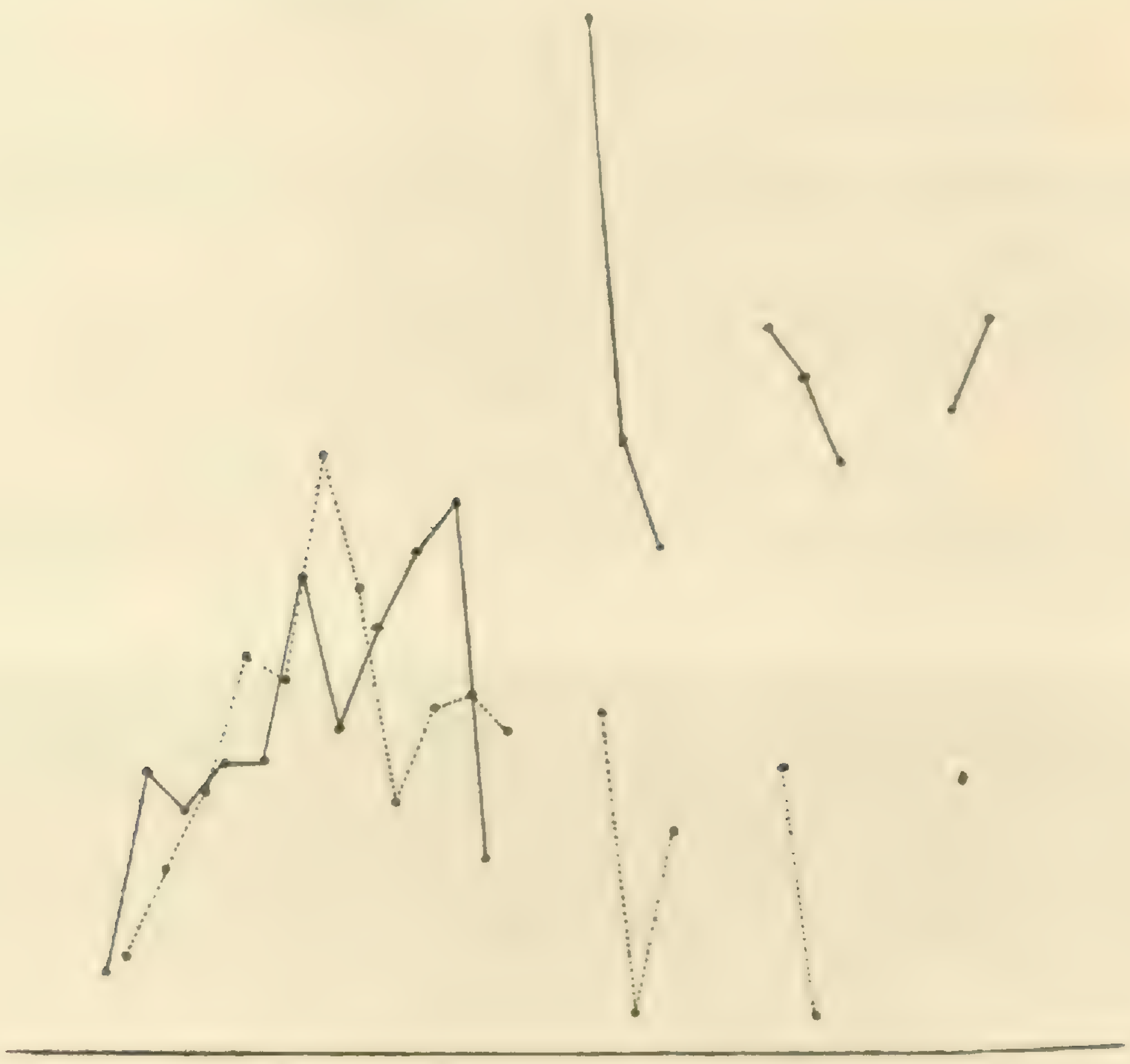
The final measurement was to the topmost leaf, above which the displaced terminal inflorescence was "fused" with an axillary branch for a distance of 11·5 mm.

The irregular internode-curve of the relatively main axis on analysis does not yield subcurves so regular as those of the true main axis; but the zigzag curve of Branch I clearly reflects the existence of two more regular subcurves, into which it can be analysed.

Phytolacca decandra. (Curves 23 *m*, 23 I–III.)

Measurements were made along an erect shoot, which was severed close to the ground, and along three branches of this.

The irregular internode-curve of the relatively main axis produces on analysis two subcurves that are less irregular, but do not give strong indication in favour of the view



that the phyllotaxis is derived from the opposite type. But the internode-curves of the branches, on analysis, lose their marked zigzag character, and yield regular and consistent internode-subcurves and displacement-subcurves. The likeness of the subcurves of Branch I (Curve 23 I) of this specimen to those of the branch of *P. esculenta* (Curve 22 I) is too close and characteristic to be merely accidental; in each case a double maximum of the displacement-subcurve most probably represents transition from the normal to the descending form of curve.

Measurements along the erect shoot:—

10·5, 12·5, *36*, 24, *31·5*, 34, *38·5*, 52, *39*, 49·5, *61·5*, 78, *42·5*, 60·5, *55·5*, 33, *66*, 45·5, *72*, ×, 46·5, *25·5*, 43.

The last measurement was from the topmost foliage-leaf to the lowest flower of the inflorescence, whose axis was "fused" with the highest branch for a distance of 31 mm. The × denotes the position of insertion of the lowest measured branch (Branch I). Branch II was inserted in the axil of the next higher leaf, and Branch III in the axil of the one above this (that is, the highest leaf).

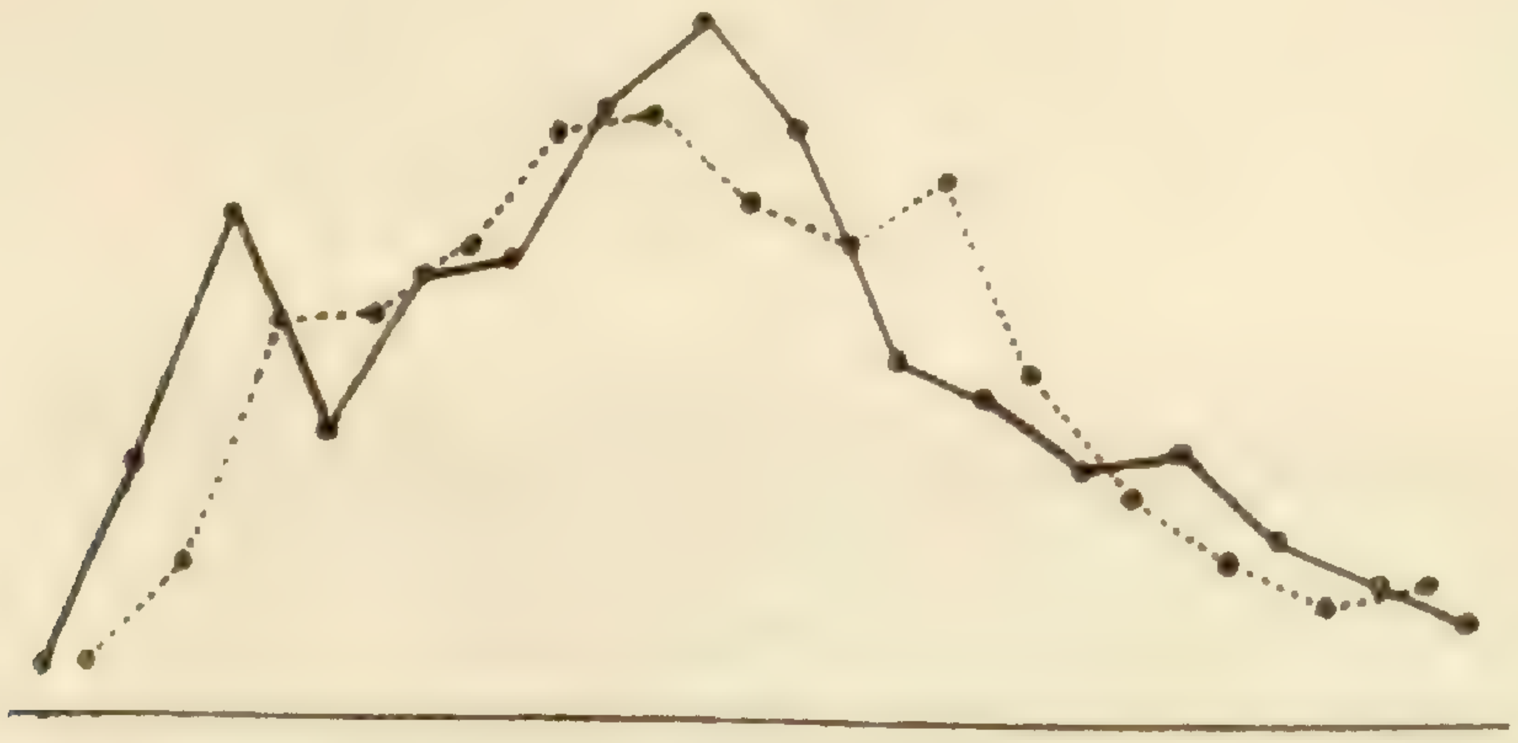
The following are the measurements made along the branches :—

Branch I. . . .	*136*	45	*80·5*	5·5	*66*	29·5	Last measurement was to the topmost leaf, above which was the terminal inflorescence.
„ II . .	*96*	38	*89*	5	*77·5*	. .	Above the last measurement the axis was broken off.
„ III . .	*85*	37·5	*97*	. .	. .	. .	Above the last measurement was the terminal inflorescence.

(The measurements of this specimen are not accurate to half a millimetre, as the stems were so thick and their forms were such that it was difficult to determine the exact corresponding points of insertion of the different leaves.)

Phytolacca polyandra. (Curve 24.)

A seedling plant was uprooted in September, and showed at the base of its stem two opposite large buds, both flanked on each side by a smaller bud. Higher up and decussate with these large buds were two that were obviously in the axils of fallen leaves, which, however, were not inserted at the same level. The succeeding two pairs of leaves



24.

showed the decussate design, and the next pair tended towards it, though the angles separating the two leaves were clearly not 180°. In fact the phyllotaxis at the base of this seedling much resembled that of *Phytolacca esculenta*. The following were the measurements made, commencing at the lowest two opposite buds :—

0, *3*, 3 (*circa*), *13·5*, 8·5, *26*, 20·5, *14·5*, 21, *23*, 25, *24·5*, 31, *32·5*, 32, *37*, 27, *32*, 25, *19*, 28·5, *17·5*, 18·5, *14*, 12, *14·5*, 8·5, *9·5*, 6·5, *7·5*, 7·5, *5·5*.

The last measurement was to the topmost leaf, above which was the young terminal inflorescence. A number of the upper internodes were obviously immature.

The zigzag internode-curve is clearly capable of analysis into two consistent and fairly regular subcurves.

ERCILLA SPICATA. (Curves 25 *m*, 25 I.)

The lateral shoot measured showed at its base a number of very short internodes, which were ignored. Above these the following were the successive measurements:—

2·5, 2, 3, 3·5, 2·75, 3·5, 8, 7·5, 8·5, 9, 8·5, 12, 13, 18·5, 13·5, 8, 14·5, 17·5, 17, 13·5, 12, 8·5, 14, 21, 19, 22, 23·5, 27, 21, 19·5, 29·5, 22, 14.

A little above the last measurement the branch-end was broken off.

Branch A given off from the preceding gave the following measurements:—

15·5, 8, *30·5*, 3·5, *33*, 6·5, *11*, 20·5, *1·5*, 11·5, *6*, 6, *6*.

Above the last measurement the end of the shoot was broken off.

25 *m*. 25 I.

The irregular internode-curve of the relatively main axis when analysed does not yield two regular subcurves, and thus supplies no evidence of any primitive opposite phyllotaxis (when analysed into three subcurves these are moderately regular). But the Branch A shows an irregular internode-curve which yields two very different but almost regular subcurves, each of which is disturbed at only one point; the double maximum of the displacement-subcurve cannot, however, be assumed to be a sign of a transition from the normal (ascending-descending) curve to a descending curve, for in other cases this curve undergoes such a change later than the internode-subcurve.

PORTULACCACEÆ.

This family includes both alternate-leaved and opposite-leaved species. I examined one of the former, namely:—

CALANDRINIA PILOSIUSCULA. (Curves 26 I, I′.)

A specimen of this species was uprooted. The base of the main stem showed indistinct scars and, a little higher up, a cluster of branches. The lowest two of these were approximately opposite, and the following pair seemed to be approximately decussate in reference to them. The lowest two branches (Branches I and I′) were measured. Each ended in a terminal flower, to the peduncle of which the continuing branch was "fused." The last measurement in each case was to the topmost leaf beneath the terminal flower.

The internode-curves are irregular and zigzag, but show strong likeness to each other, and this likeness is even more striking when comparison is made between the first two-thirds of the two internode-subcurves and the two displacement-subcurves

respectively. The subcurves are certainly consistent, though they show an undulating form, and in each internode-curve there is, in the first two-thirds, a clear indication

26 I′.

26 I.

of the two subcurves acting in the reverse manner at each point—that is to say, when the one rises the other falls. The internode-curves thus indicate leaf-displacements, while the subcurves, though they harmonize with the view that the phyllotaxis was originally opposite, yet are not sufficiently regular to confirm this view strongly.

Measurements:—

Branch I: *3·5*, 2·5, *6*, 2·75, *4*, 2·75, *2·75*, 5·5, *1*, 5·75, *3*, 2, *5·5*, 2, *3·5*, 4, *2·5*, 5, *4·5*, 4·5, *3*, 4·75, *5*, 7·5, *4*, 9, *7·5*, 4·5, *6·5*.

Branch I′: *3·25*, 1, *6·5*, 3·5, *3·5*, 3, *3*, 6, *1*, 5·5, *3·5*, 2·5, *5·5*, 2·5, *3·25*, 5, *2·75*, 5·5, *2·75*, 2·75, 7, 6·5, *3·5*, 5, *8·5*, 4·5, *11·5*, 5·5, *2·5* (young).

EXPLANATION OF CURVES.

Excepting where specially indicated, the plain lines denote internode-subcurves, while the dotted lines denote displacement-subcurves.

Atriplex rosea.

Page 273.	1 *m.*	Main stem of Specimen I 38.	Natural size.
	1 I.	1st branch of ”	
		2nd ” ”	
	1 II.	3rd ” ”	
		4th ” ”	
	1 III.	5th ” ”	
		5th* ” ”	
		6th ” ”	
Page 274.	2 *m.*	Main stem of Specimen I 10.	Natural size.
	2 I.	1st branch of ”	
		2nd ” ”	
	2 II.	3rd ” ”	
		4th ” ”	
	2 III.	5th ” ”	
		6th ” ”	
Page 275.	3 *m.*	Secondary (relatively main) axis of Specimen 192.	Reduced to ⅔.
	3 I.	Tertiary axis 1 (1st branch) of Specimen 192.	
	3 II.	” 2 (2nd branch) ”	
	3 III.	” 3 (3rd branch) ”	
	3 IV.	” 5 (5th branch) ”	
	3 V.	” 5′ (accessory 5th branch) of Specimen 192.	

Page 276.	4 *m.*	Secondary (relatively main) axis of Specimen 191.	
	4 I.	Tertiary axis 2 (2nd branch) of Specimen 191.	
	4 II.	,, 4 (4th branch) ,,	Natural size.
	4 III.	,, 5 (5th branch) ,,	
	4 IV.	,, 7 (7th branch) ,,	
Page 277.	5 *am.*	Tertiary axis A of Specimen 187.	
	5 I.	Quaternary axis 1 (1st branch) on axis A of Specimen 187.	
	5 II.	,, 3 (3rd branch) ,, ,,	
	5 III.	,, 4 (4th branch) ,, ,,	Natural size.
	5 IV.	,, 5 (5th branch) ,, ,,	
	5 *bm.*	Tertiary axis B of Specimen 187.	

Salsola Kali.

Page 281.	6 *m.*	Main stem of Specimen 8.	
	6 I.	Cotyledonary branch of Specimen 8.	Natural size.
	6 II.	Second branch of Specimen 8.	
	6 III.	Third ,, ,,	
Page 281.	7 *m.*	Main stem of Specimen 10.	
	7 I.	Cotyledonary branch (*a*) of Specimen 10.	
	7 I′.	,, (*b*) ,,	
	7 II.	Second branch of Specimen 10.	Natural size.
	7 III.	Third ,, ,,	
	7 IV.	Fourth ,, ,,	
	7 V.	Fifth ,, ,,	

Chenopodium Bonus-Henricus.

Page 283.	8.	Main stem of Specimen 32.	Natural size.
,, ,,	9.	,, ,, 34.	Natural size.

Lychnis diurna.

Page 284.	10 *m.*	Relatively main shoots I and II.	
	10 *a.*	Branch *a* on shoot II.	Reduced to ½.
	10 *b.*	,, *b* ,,	
	10 *cc′.*	Branches *c* and *c′* on shoot II.	

Stellaria media.

Page 285.	11.	Main axis.	Natural size.

Cerastium arvense.

Page 286.	12.	Specimen I.	Natural size.
,, ,,	13.	,, II.	Natural size.

Mesembryanthemum echinatum.

Page 287.	14 I.	Branch I.	Natural size.
	14 II.	,, II.	

Mesembryanthemum filamentosum.

Page 288.	15.	Main axis.	Natural size.

Gomphrena decumbens.

Page 289.	16 *m.*	Main axis.	
	16 I.	Branch I (plain line) : Branch I′ (dotted line and ×'s).	Reduced to ½.
	16 II.	,, II ,, ,, II′ ,, ,,	

	16 III.	Branch III (plain line): Branch III′ (dotted line and ×'s).	Reduced to ½.
	16 IV.	,, IV ,, ,, IV′ ,, ,,	
	16 V.	,, V ,, ,, V′ ,, ,,	
	16 VI.	,, VI (a plain dot): ,, VI′ ,, ,,	

Gomphrena globosa.

Page 290.	17 *m.*	Main axis.	Natural size.
	17 I.	Branch I′.	
	17 II.	,, II (plain line): Branch II′ (dotted line and ×'s).	
	17 III.	,, III ,, ,, III′ ,, ,,	
	17 IV.	,, IV′.	
	17 V.	,, V.	

Froelichia gracilis.

Page 291.	18 *m.*	Main axis.	Reduced to ⅓.
	18 I.	Branch I (plain line): Branch I′ (dotted line and ×'s).	
	18 II.	,, II.	
	18 III.	,, III (plain line): Branch III′ (dotted line and ×'s).	
	18 IV.	,, IV′ ,, ,, IV′ ,, ,,	
	18 V.	,, V.	
	18 VI.	,, VI (plain line): Branch VI′ (dotted line and ×'s).	

Amaranthus retroflexus.

Page 293.	19 *m.*	Main axis.	Reduced to ⅔.
	19 *x.*	Branch *x* on the main axis.	

Amaranthus polygonoides.

Page 294. 20. Main axis. Reduced to ⅔.

Phytolacca esculenta.

Page 295. 21. Main axis of Specimen I. Natural size.

Page 296.	22 *m.*	An erect shoot (relatively main axis) of Specimen II.	Reduced to ½.
	22 I.	Branch I on the relatively main axis of Specimen II.	
	22 II.	,, II ,, ,, ,,	

Phytolacca decandra.

Page 297.	23 *m.*	Erect (relatively main) stem.	Reduced to ⅔.
	23 I.	Branch I on the erect stem.	
	23 II.	,, II ,, ,,	
	23 III.	,, III ,, ,,	

Phytolacca polyandra.

Page 298. 24. Main stem. Natural size.

Ercilla spicata.

Page 299.	25 *m.*	Shoot (relatively main stem).	Natural size.
	25 I.	Branch A on the relatively main stem.	

Calandrinia piliosiuscula.

Page 300.	26 I.	Branch I.	Natural size.
	26 I′.	,, I′.	

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s.* to the public, and 6*s.* to Fellows; to Vols. 26–30, 4*s.* to the public, and 3*s.* to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

Second Series.—Botany.

Volume.	When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
I. Parts I.–IX. (complete).	1875–80.	8	1	0	6	1	0
II. Part I.	1881.	0	12	0	0	9	0
Part II.	1882.	0	5	0	0	3	9
Part III.	1883.	0	10	0	0	7	6
Part IV.	1883.	0	3	0	0	2	3
Part V.	1883.	0	3	0	0	2	3
Part VI.	1884.	0	13	6	0	10	0
Part VII.	1884.	0	9	6	0	7	0
Part VIII.	1884.	0	10	0	0	7	6
Part IX.	1886.	0	7	0	0	5	0
Part X.	1887.	0	3	4	0	2	6
Part XI.	1886.	0	6	0	0	4	6
Part XII.	1886.	0	8	0	0	6	0
Part XIII.	1887.	1	7	0	1	0	0
Part XIV.	1887.	0	7	0	0	5	0
Part XV.	1887.	0	10	0	0	7	6
Part XVI.	1888.	0	2	6	0	2	0
III. Part I.	1888.	3	12	0	2	14	0
Part II.	1891.	0	5	0	0	3	9
Part III.	1891.	0	7	0	0	5	0
Part IV.	1891.	0	6	0	0	4	6
Part V.	1891.	0	6	0	0	4	6
Part VI.	1891.	0	3	6	0	2	8
Part VII.	1892.	0	6	0	0	4	6
Part VIII.	1893.	0	6	0	0	4	6
Part IX.	1893.	1	8	0	1	1	0
Part X.	1894.	0	10	0	0	7	6
Part XI.	1894.	0	3	4	0	2	6
IV. Part I.	1894.	1	0	0	0	15	0
Part II.	1894.	2	0	0	1	10	0
Part III.	1895.	2	10	0	1	17	0
Part IV.	1895.	0	3	4	0	2	6
V. Part I.	1895.	0	9	0	0	6	9
Part II.	1895.	0	12	0	0	9	0
Part III.	1896.	0	6	0	0	4	6
Part IV.	1896.	1	0	0	0	15	0
V. Part V.	1896.	0	14	0	0	10	6
Part VI.	1896.	0	4	0	9	3	0
Part VII.	1897.	0	4	0	0	3	0
Part VIII.	1897.	0	6	0	0	4	6
Part IX.	1899.	0	12	0	0	9	0
Part X.	1899.	0	6	0	0	4	6
Part XI.	1899.	0	7	0	0	5	0
Part XII.	1899.	0	12	0	0	9	0
Part XIII.	1900.	0	1	6	0	1	2
Part XIV.	1900.	0	3	0	0	2	3
Part XV.	1901.	0	6	0	0	4	6
VI. Part I.	1901.	1	10	0	1	2	6
Part II.	1901.	0	6	0	0	4	6
Part III.	1902.	0	18	0	0	13	6
Part IV.	1903.	0	8	0	0	6	0
Part V.	1903.	0	8	0	0	6	0
Part VI.	1903.	0	12	0	0	9	0
Part VII.	1904.	0	12	0	0	9	0
Part VIII.	1904.	0	12	0	0	9	0
Part IX.	1904.	0	7	0	0	5	3
Part X.	1904.	0	14	0	0	10	6
Part XI.	1905.	0	4	0	0	3	0
VII. Part I.	1904.	0	5	0	0	3	9
Part II.	1905.	0	6	0	0	4	6
Part III.	1906.	0	3	0	0	2	3
Part IV.	1906.	0	7	0	0	5	3
Part V.	1907.	0	10	0	0	7	6
Part VI.	1907.	0	4	0	0	3	0
Part VII.	1907.	0	6	0	0	4	6
Part VIII.	1908.	0	5	0	0	3	9
Part IX.	1908.	0	2	6	0	2	0
Part X.	1908.	0	7	0	0	5	3
Part XI.	1909.	0	4	0	0	3	0
Part XII.	1909.	0	12	0	0	9	0
Part XIII.	1909.	0	5	0	0	3	9

2nd Ser. BOTANY.] [VOL. VII. PART 14.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

THE STRUCTURE AND AFFINITIES OF DAVIDIA INVOLUCRATA, BAILL.

BY

A. S. HORNE, B.Sc., F.G.S.,

MARSHALL SCHOLAR AT THE ROYAL COLLEGE OF SCIENCE, LONDON.

(*Communicated by* Prof. J. BRETLAND FARMER, F.R.S., F.L.S.)

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

November 1909.

XIV. *The Structure and Affinities of* Davidia involucrata, *Baill.* *By* A. S. Horne, *B.Sc.*, *F.G.S.*, *Marshall Scholar at the Royal College of Science, London.* (*Communicated by* Prof. J. Bretland Farmer, *F.R.S.*, *F.L.S.*)

(Plates 31–33.)

Read 18th March, 1909.

Introduction.

DAVIDIA was first discovered by the Abbé David near Mupin, in the mountainous province of Szechuen in Western China, on the borderland of Tibet. This tree has a remarkable appearance, which has been well described by those who have seen it in its native habitat, where it grows amongst *Cerasus*, *Corylus*, *Quercus*, and other trees, at a height of about 2000 metres. Two species are enumerated in the 'Index Kewensis'—*Davidia involucrata*, Baill., and *Davidia tibetana*, David. The specific name *tibetana* is used by the Abbé David in a letter to Franchet in 1881, and appears to be synonymous with *involucrata*, since he writes *: "l'arbre curieux que M. Baillon a bien voulu appeler de mon nom, *Davidia tibetana* . . . . ." The first dried material appears to have been placed in the Paris Herbarium with other "Plantæ Davidianæ." In 1889, during a six months' excursion, A. Henry found a single tree in East Szechuen and from this source obtained fruits and seeds. A fully developed inflorescence of his went to the British Museum of Natural History. In 1904 a number of trees were seen by E. H. Wilson in the same province, and seedlings and a series of inflorescences and fruits were brought to this country. Wilson states that there are two distinct varieties of *Davidia involucrata*—the one described by Baillon with large showy bracts, and another with smaller bracts. A description and full-page illustration from dried material collected by Wilson of *Davidia involucrata* appeared in the 'Gardeners' Chronicle' of April 11, 1903. *Davidia* is again figured on June 2, 1906, in the same journal, from a photograph taken in Vilmorin's nursery, where the plant flowered for the first time in Europe.

Davidia was originally described by Baillon †, and was placed by him near *Nyssa* among the Combretaceæ. An excellent figure of a twig bearing a fully developed inflorescence is given by A. Franchet ‡ in 'Plantæ Davidianæ.' The anatomy

* Franchet, Plant. David. i. p. 161.

† Baillon in 'Adansonia,' x. (1871) p. 114.

‡ Franchet in Nouv. Arch. Mus. 2e sér. (1888) pl. 10.

of *Davidia* is dealt with by Sertorius * in his "Beiträge zur Kenntnis der Anatomie der Corneaceæ" in 1893. In 1891, D. Oliver †, with Henry's fruit at his disposal, briefly described the fruit-bearing twig.

A number of seeds brought over by Wilson were germinated. The curious method of germination was described and figured by W. Botting Hemsley ‡. Grafting experiments carried out by Messrs. James Veitch and Sons upon members of the Cornaceæ and Hamamelidaceæ proved unsuccessful. The systematic position has been discussed by Harms § in his paper entitled "Die Gattungen der Cornaceen." This author places *Davidia* and *Nyssa* among the Cornaceæ in the groups Davidioideæ and Nyssioideæ respectively. *Davidia* is placed among the Hamamelidaceæ, near *Fothergilla*, by J. D. Hooker in the English translation of Le Maout and Decaisne's 'Traité Général de Botanique' (p. 410), which was published in 1873; but it is referred to the Cornaceæ in Bentham and Hooker's 'Genera Plantarum.' Quite recently Wangerin ‖ has suggested a probable affinity with the Euphorbiaceæ.

The material used in this research is of the form of *Davidia* described by Baillon. It was obtained by Wilson from the trees he had seen in 1904, when collecting for Messrs. Veitch. It consisted of what appeared to be a very complete series from very young inflorescences to fully developed fruits. The material proved somewhat deceptive and somewhat analogous to inflorescences of *Symphoricarpus*, Juss., picked in autumn, which bear apparently all stages from flower to fruit, although the greater part of the inflorescence is generally sterile. Serial sections were made of a number of ovaries, but only a single doubtful case of fertilization was observed. The young fruits yielded very meagre information with regard to post-fertilization changes within the embryo-sac. Sufficient information was obtained, however, to establish the morphological character of the tissue containing reserve food which invests the germinating embryo. It was found exceedingly difficult to extract embryos from the mature fruit owing to the excessive hardness of the endocarp.

The paper is divided into the following sections:—

1. Vascular structure of the seedling and general anatomy.
2. Morphology of the inflorescence and flower.
3. Vascular structure of the inflorescence.
4. Vascular structure of the ovary.
5. Discussion of the nature of the inflorescence and flower.
6. Structure of the ovule and seed.
7. Discussion of affinities and summary.

* Sertorius in Bull. Herb. Boiss. i. (1893) p. 469 &c.

† D. Oliver in Hook. Ic. Pl. t. 1961.

‡ Hemsley in Journ. Linn. Soc., Bot. xxxv. (1903) p. 556.

§ Harms in Ber. Deutsch. Bot. Gesellsch. xv. (1897) pp. 21–29.

‖ Wangerin in Eng. Bot. Jahrb. xxxviii. (1906), Beibl. No. 86, pp. 1–88.

1. Vascular Structure of the Seedling and General Anatomy.

The vascular structure of the seedling of *Davidia* is of interest on account of its degree of variability. The vascular skeleton before secondary growth occurs consists of two opposite cotyledonary traces, each composed of two or three bundles. These traces alternate with plumular vascular tissue (Pl. 32. figs. 1, 4). Each cotyledon trace passes intact throughout the hypocotyl into the root. In the root, however, adjacent phloem horns of the opposed arcs ultimately unite (Pl. 32. figs. 3, 8). Whether the cotyledonary trace consists of two or three bundles, the xylem of each bundle bifurcates, the parts diverge towards mid-hypocotyl—change from endarch to exarch structure taking place by rotation of protoxylem pairs towards one another—and then converge towards the root (Pl. 32. figs. 1–8). Each xylem group of the trace thus preserves its identity. Each phloem group bifurcates, the parts diverge downward towards the root, and portions of adjacent phloem groups unite. When the cotyledonary trace is two-bundled the root is tetrarch, when three-bundled, at first hexarch. The behaviour of the xylem in converging towards both ends is similar to that in the well-known case of *Fagus sylvatica* and appears to differ only in degree from the cases mentioned by Sargent, Hill, and others, where the xylem of a trace-bundle becomes exarch without an appreciable divergence of parts. Early developmental stages of this system are well seen in the very young germinating seedling before the endosperm has entirely disappeared. The cotyledonary traces are distinct and consist each of a single arc of conducting tissue. The bundles of the trace become distinguishable during the growth of the petiole. In the hypocotyl, when the arrangement is symmetrical, there are eight or twelve protoxylem groups converging in pairs downward towards the as yet undifferentiated root and upward into the cotyledonary arc. In the case of tetrarch seedlings the groups are not always of equivalent value and their elements may be somewhat scattered. In subsequent growth these irregularities become emphasized and one or more of the protoxylem groups become subordinate or apparently suppressed. The four protoxylem groups at the horns of the arcs do not become suppressed, but the bundles associated with them show an increase in size correlated with subordination or suppression of the median groups. There is, therefore, almost a complete series of stages towards the development of four xylem strands passing from cotyledon to root without bifurcation, each individual strand rotating, so that the xylem strands of each trace rotate toward one another into a tetrarch root.

Secondary growth sets in at the time when the first foliage leaves are unfolding, and the plumular vascular tissue increasing in importance in the hypocotyl supplants the cotyledonary system. At this time the fibres become prominent and increase in number in transverse section owing to sliding growth, but the characteristic *arc-shaped* appearance in tangential section (see p. 306) is not yet well-marked. Their distribution in the hypocotyl is indicated by the diagram (Pl. 32. fig. 9) and the following table:—

Position in Diagram.	Number of Fibres.	Remarks.
E	123	Beginning of cork formation. (E–K)
F	116	
G	114	
H	89	
I	57	
J	40	
K	27	
L	10	Trace of endodermis.
M	0	Complete endodermis.

The vascular structure of the seedling of *Davidia* is in a state of flux, and it will be shown that this condition prevails not only in the vascular structure of the seedling, but also in the building of the inflorescence and the flower.

The tissues of *Davidia*—the outer cortex, medullary rays, phloem parenchyma, xylem, sheath and nest-cells of the central cortex—are full of starch. Tannin occurs in the peduncle and fruit. Calcium oxalate is very generally distributed, more often in crystal clusters or in clinorhombic form. The medullary rays are narrow, some two or three cells broad. In radial sections the cells are brick-shaped. In some rows the cells have their long axis horizontal, in others the cells have their long axis vertical—the procumbent and upright cells of De Bary *. Certain cells are septate with single crystals in each chamber. The sieve-tubes are of medium size and resemble those described by A. W. Hill † for certain Angiosperms. In all the material examined the callus areas and markings were prominent, and showed up well when treated with methyl blue (Grübler). The companion cells are comparatively large. They are divided by thin septa into a number of compartments. Each chamber contains a more or less corroded clinorhombic crystal of calcium oxalate. These crystal rows are a characteristic feature of the phloem. The phloem parenchyma of *Davidia* consists of rectangular albuminous cells and squarish or irregularly-shaped crystal sacs, crystal cells, or septate crystal cells. Typical hard bast is present in the primary phloem. The fibres occur in scattered groups: we do not find in our material the "gemischten, continuirlichen Sklerenchymring" that Sertorius ‡ describes for *Davidia*. Fibres occur in all parts of the stem and peduncle. As growth proceeds, the fibres, which were originally straight, are seen to be arc-shaped in tangential section, due to tangential pulls as in *Tilia*. The walls of fibres of the first-year hypocotyl of *Davidia*, when treated with sulphuric acid and iodine, show three regions—an inner sky-blue band which merges into a middle bluish-green band, and a golden brown, less-swelling, limiting layer. Fibres of a hypocotyl some years older differ chiefly in the increased thickness of the wall, the middle band being the most extensive. There is little increase in the degree of lignification with increasing age. The fibres of *Davidia* are intermediate in composition between the white ones of *Cornus*, which contain a large proportion of cellulose,

* De Bary, Comp. Anat. p. 486.

† A. W. Hill in Ann. Bot. xvii. (1903) p. 265.

‡ Sertorius in Bull. Herb. Boiss. i. (1893) p. 623.

and the yellow ones of *Garrya*, which are almost completely lignified. The xylem consists of vessels, wood prosenchyma, and parenchyma. The degree of lignification of the two last-named elements corresponds roughly to that of the phloem prosenchyma. In *Davidia* the fibres are marked with oblique, often highly inclined, slit pits, which run in a spiral round the wall and are the cause of a curious optical effect resulting from the superposition of fibre walls (series of crosses). Pits with faint borders and with circular or elliptic apertures were observed. Sertorius's statement * that the prosenchyma is marked with bordered pits only (nur Hoftüpfel) is incorrect. The sculpturing of the vessel is scalariform or there are multiseriate rows of slit pits or of slit pits with faint borders arranged in a spiral.

2. Morphology of the Inflorescence and Flower.

The mature, polygamous inflorescence is a striking object. The flowers form a globular head. Inserted some little distance below the head are two large, almost opposite, white, sessile bracts, which, spreading from the stem, may reach a length of six or more inches. The inflorescence consists either of a number of stamens alone or of a number of stamens and a single obliquely situated hermaphrodite flower, the latter being on the side of the upper, generally larger bract. Three kinds of flowers were originally described, but those described as female may have been hermaphrodite flowers bereft of their stamens. The stamens are some five or six hundred in number and are, before maturity, seated in tiny foveoli. By subsequent toral growth, the depressions become elevations, so that the groups appear minutely pedicellate. The stamens emerge in irregular circles and ellipses in any number from one to about twelve, the greater number in groups of five or six. They are without a trace of perianth or anything equivalent to that structure. The mature hermaphrodite flower is obscurely pedicellate, appearing sessile on the torus. It is always obliquely seated. Disregarding the stamens, its symmetry is zygomorphic, and it is so in very early stages owing to one-sided development. The style arches towards the less developed side. The shape of the inferior portion when very young is obliquely hemispherical, tapering towards the somewhat cylindrical, curved style. By subsequent growth the ovary becomes ellipsoidal (Pl. 31. figs. 7, 8, 9). The plane of zygomorphic symmetry through the ovary may coincide with a vertical plane through the axis of the inflorescence or it may lie in an oblique tangential plane. The deviation from the vertical is from 30° to 45°. The epigynous stamens vary in number from fifteen to twenty-six, forming a zone at the base of the style (Pl. 31. fig. 2). The stamens are not hypogynous, as stated by Harms † in his account of the Cornaceæ in Engler's systematic work. Baillon ‡ in his original account describes female flowers bearing a subepigynous perianth and hermaphrodite flowers similar to female, but with hypogynous stamens within the perianth. This description is also found in the 'Histoire des Plantes' §. In a footnote in the

* Sertorius in Bull. Herb. Boiss. i. (1893) p. 635.

† Harms in Engl. u. Prantl, Nat. Pfl., Teil iii. Abt. 8, pp. 250–270 (1898).

‡ Baillon in 'Adansonia,' x. (1871) p. 113.

§ Baillon, Hist. Pl. vi. p. 271.

English translation of this work, however, his description of the female flower is modified and he states that the inferior ovary is surmounted by an epigynous "calyx." Baillon's "calyx" or perianth consists of numerous, small, unequal, subulate folioles. I was unable to find a definite perianth (Pl. **31.** figs. 2, 4, 5), but between the points of insertion of the stamens there are exceedingly minute excrescences, which, in my material, are nothing more than the natural areas raised by contrast between two stalked organs inserted close to one another. The perianth figured in 'Plantæ Davidianæ' (ii. p. 303) seems to be an exaggerated expression of these minute bulges. The perianth described by Harms, in the work referred to above, is not represented in the original figure of the hermaphrodite flower accompanying the text.

In the youngest stages, before the elongation of the style, the stamens of the hermaphrodite flower are on a level with those of the male flowers (Pl. **31.** fig. 4). The presence of the hermaphrodite flower is thereby completely masked. Its position when present is always indicated by the upper bract, which has an apical hood that is adpressed to the surface of the inflorescence immediately above the position of the stigma. Its under surface is hairy and the hairs interlock with the anthers. At this stage the style is practically undifferentiated and the stigmatic rays small. By the growth of tissue the stigma gradually emerges from the hooded apex of the bract, the rays spreading radially outward. Finally, the bract expands and the hermaphrodite flower becomes fully visible. Its stamens project above the level of the surrounding male flowers (Pl. **31.** fig 1).

The ovary has generally from six to nine loculi—the mean number in the material examined being seven. The number of stamens varies independently of the number of loculi. The correlation table (Pl. **32.** fig. 10) shows the nature of the variation. The loculi are uniovular. The ovules are attached axially as in *Sambucus*. They are situated radially in the mature ovary with the vascular bundle of the raphe between the axis of the ovary and the nucellus.

3. Vascular Structure of the Inflorescence.

The bracts of very young inflorescences are inserted a little below the globular head of flowers. As growth proceeds they become displaced downwards. The vascular structure of the peduncle between the torus and bracts is curious. This structure was studied by means of serial sections of young inflorescences. It is illustrated by diagrams made from sections at different levels (Pl. **33.** figs. 1–14).

The emergence of the stamens in groups corresponds to vascular groups in the torus. The staminal bundles pass into regular or irregular cylinders. The adjacent bundles of particular groups begin to anastomose just beneath the epidermis. The cylinders converge and amalgamate with others or pass direct into a plexus of vascular tissue in the torus. Fig. 1 represents a superficial section through the top of a torus. The dots in this case represent individual bundles and each group of bundles corresponds to a similar number of stamens. In subsequent diagrams the dots represent either single or

composite bundles according as they are near to or away from the periphery. In fig. 2 the bundles are anastomosing. In fig. 4 the groups of bundles seen in figs. 1, 2, and 3 have lost their individuality in four small masses of vascular tissue which form a part of the toral plexus (figs. 5, 6).

The vascular tissue of the peduncle consists, below the point of insertion of the bracts, of a cylinder of closely adjacent bundles. Above the insertion of the bracts, four, five, six, or seven of these become prominent, projecting outwards a little from the ring (the behaviour varies). When there are six of these, three of them point towards one bract and three towards the other (the two bracts are not directly opposite one another). At the same time the axial cylinder, now six-rayed, becomes slightly one-sided, retaining this character throughout peduncle and torus. The course of the cylinder is oblique in the torus, due to the bulging of one side. It receives in the torus the mass of vascular tissue from the stamens. The vascular ring of the obliquely situated hermaphrodite flower is inserted on the oblique end of the cylinder. These points are illustrated by figs. 6 to 14. In this series four bundles project from the axial cylinder (fig. 10). Fig. 8 represents a section through the middle of the torus showing the vascular plexus. The lines extending inward from the periphery represent the vascular tissue of the stamens inserted at that level.

Some of the staminal vascular tissue projects downwards into the top of the peduncle and becomes gradually aggregated into three peduncular bundle-groups on each rayed side of the cylinder in the torus. The middle group of each set of three is at first associated with the projecting bundle of the axial cylinder opposite it, and this association may continue some millimetres below the torus. The six little groups become ultimately free in the cortex of the peduncle as more or less irregular, slender cylinders as far as the bracts. Just above the insertion of these organs, the appearance of the groups in transverse section is that of vascular arcs with xylem inversely orientated. The many bundles of each bract unite at the sessile base into a three-bundled trace. The bundles of the trace enter the peduncle with their xylem normally orientated. Each trace becomes confluent with the three opposed inversely orientated arcs on its particular side and does not become attached to the axial cylinder. A vertical section through a confluent trace-bundle and arc shows that they converge to a point, the opposed xylems being connected at an acute angle within the surrounding phloem. The bundle-groups can be distinguished in fig. 9, which represents a section from the base of the torus; a little lower the bundle-groups are distinct (fig. 10), but the median bundle of one side only is confluent with the corresponding projecting bundle of the axial cylinder. Below this level the groups become arc-shaped as explained above. The bundles of the bracts are shown collecting into the trace-bundles which become confluent with the peduncular arcs in figs. 12 and 13.

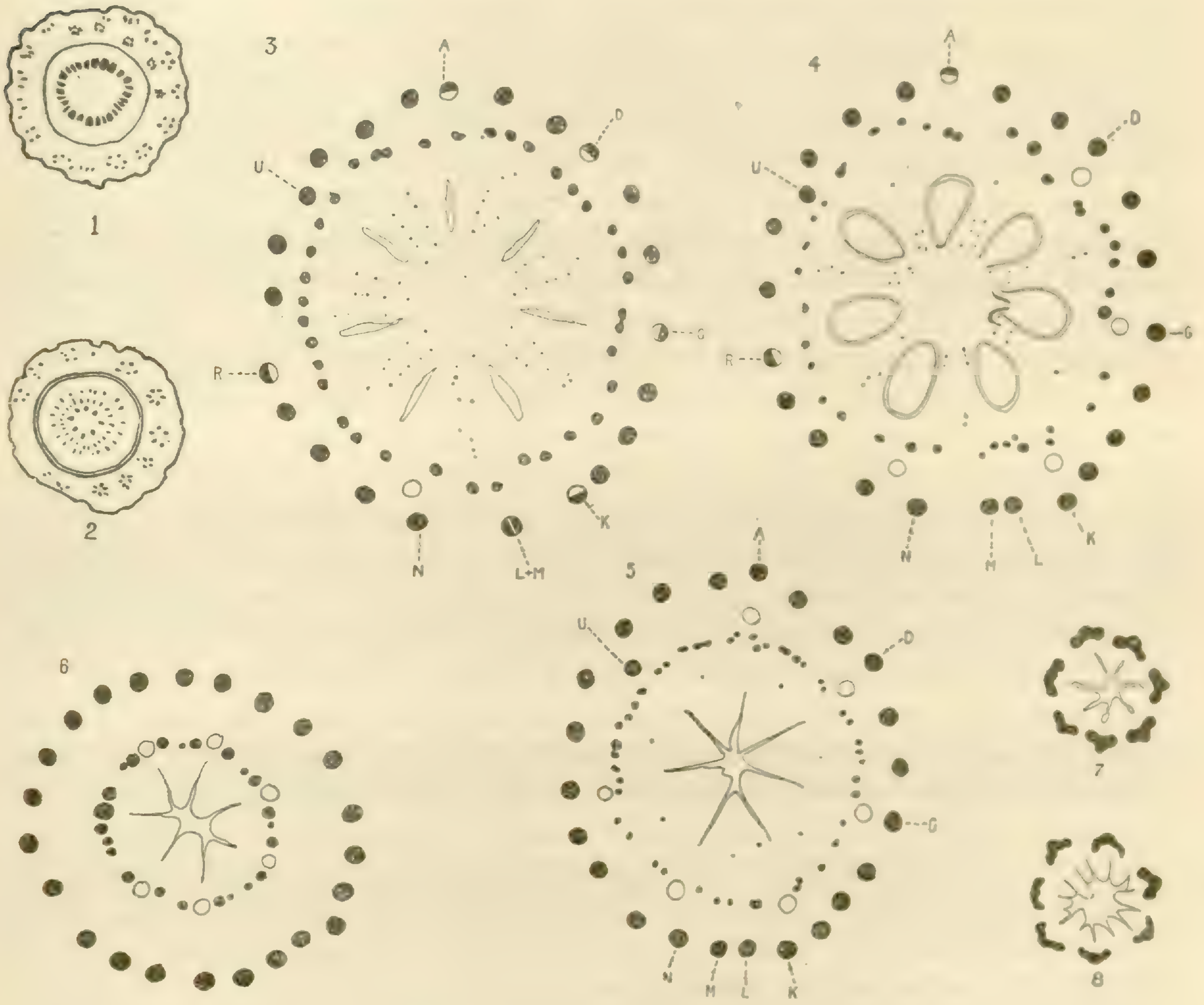
The vascular structure of the inflorescence varies considerably in detail. Rarely there are less then six cortical peduncular bundles. There is also variation in the attachment of these bundles to the vascular axis; but the lateral ones join it usually in the torus.

4. Vascular Structure of the Ovary.

The vascular supply to the hermaphrodite flower emerges from the torus into the obsolete pedicel as a single complete cylinder of closely adjacent bundles, which segregate at the base of the flower into three concentric cylinders:—(1) an outer peripheral cylinder; (2) an inner peripheral cylinder; (3) a radial or septal cylinder consisting of fine strands (text-figure, p. 311).

The inner peripheral cylinder expands in the body of the ovary and surrounds the loculi. The bundles of the cylinder branch and anastomose among themselves. In the superior part of the ovary the vascular structure becomes angular, owing to the presence of bundles from the outer cylinder which take up a position behind the loculi. This structure tapers towards the style, the smaller bundles collecting at the seven angles (in heptamerous ovaries) about the bundles which are connected with the outer cylinder, and, finally, seven arc-shaped bundles are left which extend into and occupy a "dorsal" position in the stylar lobes. In transverse sections through the superior portion of the ovary the outline of the inner vascular system is polygonal. The behaviour of the septal bundles is not easy to follow. In the inferior portion of the ovary they split into a number of fine, thread-like strands whose xylem up to the time of fertilization is undifferentiated. These strands diverge upward, forming three small groups in each septum. The strands of the outer group extend towards the inner peripheral ring, but some die out. Two little groups extend inwards and are concerned in feeding ovules on either side—the single ovule of each loculus being fed by strands from the two adjacent septa. The later history of these strands is masked by post-fertilization changes leading up to a general sclerosis of this region, which ultimately becomes the excessively hard endocarp. The strands of the outer peripheral cylinder correspond fairly accurately in number to the staminal bundles, and the greater number pursue an independent upward course in the body of the ovary as far as the point of insertion of the stamens. Some of the bundles branch during their course, giving off a bundle which joins the inner cylinder in the superior portion of the ovary in the manner described above. At first this behaviour was thought to be an occasional irregularity, but the examination of a number of ovaries in serial section showed conclusively that it was of greater significauce. It was found that the bundles behaving in this way tended to be equal in number to the loculi. In all cases the bundles in question formed the angles of the upper portion of the inner vascular system ("dorsal" position). In a heptamerous ovary, seven bundles were found behaving irregularly. Six of these were composite in character. The stamens associated with them emerged opposite the loculi, so that they may be regarded as forming a definite whorl. Diagrams made from serial sections of this particular ovary are shown in the text-figure on p. 311. Diagram 1 shows the cylinder of vascular tissue in section as it appears in the torus immediately below the pedicel. The small dots represent staminal bundles which occur in groups. In diagram 2 the pedicel is free from the torus and the vascular tissue has branched, forming three concentric cylinders. In the following diagrams the bundles of the outer vascular cylinder are represented by large dots, the bundles of the inner cylinder by smaller ones, and the septal strands by very

small dots. The composite bundles, A, D, G, K, N, and R, of the outer cylinder are represented by black and white dots. One of these, N, has already divided (diagram 3). Higher up in the ovary (diagram 4) the bundles D, J, and K have divided. In diagram 5 all the composite bundles have divided and the inner branches occupy a "dorsal" position. In the region of the style the bundles of the inner cylinder collect about the "dorsal"



Vascular structure of the ovary of *Davidia*.

bundles (diagram 6), so that ultimately seven arc-shaped bundles are formed (diagrams 7, 8). The seventh bundle, U, behaves exactly as the others—except that it does not give rise to a staminal bundle. The three groups of small septal strands are shown in diagram 4 in the septum between the loculi in a line with K, N, respectively. The septal strands are seen entering the ovule which is opposite G. One of the strands, LM, of the outer cylinder divides to form two (diagrams 3, 4).

5. Discussion of the Nature of the Inflorescence and Flower.

The reduction of an inflorescence to its ultimate unit is shown by an evolutionary series. Some of the Cornels and Viburnums have their flowers arranged in cymose umbels. In *Cornus sanguinea* and *Viburnum Lantana* there is no definite arrangement in groups, but in *Viburnum stellulatum* the tendency of the flowers forming the umbel is to a triflorous arrangement with articulate pedicels. The expression of this tendency is complete in *Aucuba japonica*, where we have racemes of opposite and decussate cymose branches of the second order, a number of rudimentary flowers occurring about the point of articulation of the fertile ones. The Garryas have their female flowers in spikes of opposite and decussate, biparous, triflorous cymes or have the cymes reduced to single flowers. Among the Nyssas we have the limit of reduction. The polygamous inflorescence of the *multiflora* group consists of a short spike or capitulum of male and female flowers. In *N. sylvatica* the inflorescences are few-flowered and in a particular case consisted of hermaphrodite or female units borne in groups of three at about the same level on the torus. In *N. uniflora* there is but a solitary flower. The Nyssas in this respect show some resemblance to the inflorescence of *Davidia*, which generally includes a single, obliquely situated, hermaphrodite flower.

In *Viburnum stellulatum* certain branches of the inflorescence may develop as one organ and bear at the top the small ultimate cymose branchlet. The individual vascular cylinders may remain distinct in the common ground-tissue, or may develop as one narrow, irregularly-shaped cylinder, so that the inflorescence is complete (Pl. 33. figs. 15, 16). The floral organ or "double flower" of *Prunus serrulata** is an inflorescence and presents in some ways a remarkable parallel to *Davidia*. There is generally a single, more or less obliquely-situated terminal bud, surrounded by a number of others which have grown together laterally with partial suppression of parts. The vascular structure of the common stalk ("peduncle") consists of a number of small cylinders which originate from the single axial cylinder of the twig (Pl. 33. fig. 17). There is every reason to believe that a process of this kind has had its share in the inflorescence-building of *Davidia*, which has culminated in the production of a globular head of flowers accompanied by vascular complexity in the torus.

The following considerations materially modify the original conception of the flower of *Davidia*:—(1) the total absence of a perianth; (2) the epigynous not hypogynous stamens; (3) more definite information with regard to the number and nature of the epigynous stamens. Baillon † believed the male flowers of the inflorescence to consist each of a single stamen; Oliver ‡, on the other hand, considered them multistaminate, since the stamens are inserted in little foveoli on the torus and emerge in groups. In this connection the following evidence is available:—(1) the stamens emerge in groups

* The Double Chinese Cherry, introduced from China in 1822. It blooms in April and has white or rose-tinted flowers.

† Baillon in 'Adansonia,' x. (1871) p. 114.

‡ D. Oliver in Hooker, Ic. Pl. t. 1961.

seated in small pits which ultimately become raised; (2) the number varies from one to twelve, approximately, emerging chiefly in groups of five or six; (3) the emergence is chiefly in irregular circles or ellipses; (4) the vascular bundles of individual groups of stamens, with some coalescence, form few-bundled irregular cylinders which merge into others in the neighbourhood of the general plexus; (5) the stamens are not articulated and there is no direct evidence that we are dealing with reduced male flowers. This is a case which needs a comparison with fairly closely related forms. The apparently isolated position of *Davidia* renders this a difficult matter. There are several natural orders with which *Davidia* is supposed to have some affinity, and two of these, the Euphorbiaceæ and Hamamelidaceæ, show reduction series with regard to the male flowers. Among the Euphorbiaceæ there is the well-known *Anthostema-Euphorbia* series. In *Anthostema* the male flowers are unistaminate, each stamen being articulate and surrounded at the point of articulation by a toothed perianth. This structure is replaced in *Euphorbia* by an articulate stamen. In *Euphorbia* the male flower has almost lost its individuality. We might consider that the inflorescence of *Davidia* is made up of a globular head of similar flowers which have completely lost their individuality. That the negative evidence of *Davidia* is of little value may be better realized from a study of the subtle case of *Altingia* (Hamamelidaceæ). The stamens in this genus are arranged in a spike. This organ affords no clue whatever in some of the species, but in others there is some trace of a bract associated with individual stamens. If it were possible to telescope-up inflorescences of this kind, it is conceivable that a structure might result resembling the male inflorescence of *Davidia* both morphologically and in vascular structure. The above-mentioned evidence may be used with equal force in support of either view, so that the case becomes purely speculative.

The solution of the problem depends upon an interpretation of the peculiar morphology of the hermaphrodite flower. In earlier discussions on this subject, when the number of the epigynous stamens was uncertain and the course of the staminal bundles in the ovary unknown, it was difficult to compare or contrast the hermaphrodite flower with known forms with the exception of the apetalous, perigynous flowers of *Fothergilla*. In both cases the ovary is surrounded by a ring of stamens varying in number. The perigyny of *Fothergilla* alone is not an insurmountable barrier, since transition from perigyny to epigyny may be found within the genus *Saxifraga*, and the Hamamelidaceæ comprise hypogynous, perigynous, and epigynous forms. Apart from perigyny, however, the ovaries of the Hamamelidaceæ and *Davidia* are fundamentally dissimilar in many respects and the resemblance is a purely superficial one. The formation of a single ring of stamens such as occurs in *Davidia* and *Fothergilla* is not difficult to explain. Two possible processes may be illustrated by the hybrids *Garrya Thuretii* and *Corylopsis spicata* respectively. The male flowers of *Garrya Thuretii* are remarkable. A single-stalked structure arises in the axil of each bract. This is made up of three congenitally-fused flowers. There are five or six petals irregularly situated. The stamens vary in number (about ten or eleven). Some of these alternate with the petals, whilst four, more or less rudimentary and more centrally situated, surround

ovarian rudiments. The central group of stamens, together with the ovarian rudiments, represents the median flower with which the lateral, partially aborted flowers have been united so as to form one floral organ. In *Corylopsis spicata* all stages may be found in the replacement of petals by stamens, so that a ring of twice the normal number of stamens may surround the ovary. A process of the latter kind would explain both the origin of the ring of stamens and the absence of a perianth in *Davidia.*

It might be argued that some or all of the stamens are really toral stamens which have been caught up in the growth changes inducing epigyny through successive generations in just such a way as the epigynous tendency asserts itself in the genus *Garrya*, with the result that bracts are inserted superiorly on the ovary wall. There is no direct evidence in favour of this view. At the same time the irregularities in the number of stamens in the staminal zone come within the limits of reasonable variation. In such forms as *Cornus mas* and *C. sanguinea* there is extremely little variation in the flower. In *Sambucus nigra* sepals vary in number independently of the number of the loculi of the ovary. The proportion of normal to exceptional flowers in these respects is $\frac{269}{47}$ out of 316 examined. In *Hedera Helix* var. *arborea* the stamens vary independently of the loculi. Only 18 flowers were observed, and in these the loculi varied from 4 to 7 and the stamens from 5 to 9 (Pl. 32. fig. 12). The table for *Davidia,* which, it must be remembered, refers to a very limited quantity of material, resembles that of *Hedera Helix* var. *arborea* in the degree of variation. The most frequent correlation is that of seven loculi with twenty-one stamens (Pl. 32. fig. 10). The tables also indicate a tendency towards two means, both multiples of five. The number of stamens in the epigynous zone of *Davidia* has been described as five by Hemsley *, while the loculi are stated to vary from 5–10. If, as Wilson states, there be more than one form of *Davidia*, the range of variation may be considerably greater than that shown by the table.

The idea of a serial arrangement of stamens suggested by the correlation table is strongly reinforced by the anatomical evidence, which points to the existence of a definite whorl of oppositilocular stamens, the peculiar orientation itself suggesting an arrangement of stamens in series. The stamens appear to vary independently of the number of loculi. In a few cases they are three times as many as the mean number of loculi. Greater stress should be laid upon this correlation than it apparently deserves, since variation itself would account for considerable irregularity in the correlation table.

Taking into account flowers of the whole inflorescence, the following points are significant:—(1) The existence of a whorl of oppositilocular stamens, which points to an arrangement of stamens in series. (2) The number of loculi, which is generally six or seven, seven being the mean. (3) The emergence of the toral stamens in groups, principally of fives and sixes. From this point of view, the hermaphrodite flower loses its anomalous aspect and becomes more definitely related to the toral stamens, which, as I have shown, emerge in groups in numbers whose mean is just below the mean number of ovarian loculi.

* Hemsley in Journ. Linn. Soc., Bot. xxxv. (1903) p. 556.

6. Structure of the Ovule and Seed.

The ovule consists of the nucellus and an extra-nucellar tissue, which may be regarded as the congenitally fused integument and raphe. Just prior to megaspore germination it is more or less ovoid, with a curved, obcuneate nucellus at its apex, pointing upwards and inclined a little towards the axis, the free portion of the integument appearing as an irregular neck around the nucellar bulge, more strongly developed on the abaxial side. At the time of megaspore germination this neck develops over the nucellar surface, leaving a circular aperture on either the right or left hand side—the micropyle. At this time the "hinge" area of the ovule is about halfway between its own apex and base. The raphal tissues lie on the placental side merging at the base into the chalaza. At maturity the point of attachment is towards the apex of the ovule owing to extensive chalazal development—the free part of the integument being the portion between the point of attachment and the apex. The integument arches over a little towards the abaxial side, its concave under surface roofing the micropyle, which is more or less triangular in section. The ovule takes up finally a radial, vertical position in the loculus—the vascular bundle of the raphe being between the placenta and the nucellus. The micropyle is directed upwards and laterally (either to right or left). A similar position of the ovule at maturity is characteristic of the Araliaceæ, Umbelliferæ, certain genera of Cornaceæ, *Amygdalus*, and the Spiræas. The mode of development of the integument and the position of the micropyle in early stages suggest an oblique insertion of the nucellus as in *Aralia* (masked at maturity by the radial position taken up by the ovule). The nucellus is of medium bulk and consists of about three concentric vertical or axial rows within the epidermis. The material proved not young enough to show the formation of these rows, the earliest stages being just prior to megaspore germination. They doubtless originate as a subepidermal plate of cells in the usual way. The cells of the rows resemble one another very closely in appearance and in staining reactions. Sooner or later certain cells, either of the same or of different rows, became active at the expense of the surrounding sporogenous tissue (sterile megaspores) in the way described by Benson * and others (Pl. 31. fig. 14). There is considerable variation in behaviour of the sporogenous tissue. The axial rows are rarely completely sterile. From this condition there are all gradations up to the germination of four or five megaspores, and perhaps more (Pl. 31. figs. 18, 19, 21). The germinating megaspores of any one ovule rarely give rise to more than one complete embryo-sac. Of the six, seven, or eight ovules in any one ovary very few were found with typical embryo-sacs. There are, however, all gradations between sterile ovaries and ovaries with all their ovules fertile—from the evidence of germinating seeds. The abnormalities in connection with the embryo-sac are numerous, relating to the number, disposition, and form of the nuclei. Sacs may attain the two- and four-celled stage without nuclear differentiation, and then disintegrate (Pl. 31. fig. 18). Frequently the nuclei of sacs in the four-celled stage resemble synergids in the micropylar end and antipodals in the chalazal end. Again,

* Benson in Trans. Linn. Soc., 2nd ser. Bot. iii. (1894) p. 412 &c.

there may be two synergids, two antipodals, the polar nuclei, and no egg-cell (Pl. 31. figs. 20, 21). Sometimes there is an increase in the number of antipodal nuclei (Pl. 31. fig. 24). The antipodals are of the haustorial type described by many authors and appear to persist only in sterile ovules. An abnormal number of polar nuclei was occasionally observed—in one case as many as seven (Pl. 31. fig. 22). Deceptive appearances are sometimes presented in sterile embryo-sacs when synergid nuclei with three or more nucleoli are found above a single fusion nucleus with a large nucleolus derived from unfertilized polar nuclei. Many sterile sacs persist for a long time after fertilization time and contain an active antipodal haustorium and occasionally beaked synergids: the body of the attenuated sac is occupied by a mass of protoplasm containing the large fusion nucleus with very large nucleolus. A similar fusion nucleus is formed in sterile sacs of *Cornus*. In two or three instances there were indications of a possible visit of a pollen-tube. There appears to be a single genuine case of fertilization where in a normal sac a small nucleus, presumably the male, occurs in juxtaposition to the egg-nucleus. Owing to the degree of sterility of the material, the presence of partially destroyed nucellar cells and of embryo-sacs in various stages of disintegration, and of multinucleolate nuclei, it is impossible to record anything definite about fertilization. In early phases of megaspore development the encroachment upon nucellar tissue may extend to the epidermal layer, rupturing it and exposing the young embryo-sac. Where there are several developing sacs, the internal limiting layer and its subjacent cells of the integument itself may be attacked. There is no recognizable "calotte" as there is in *Aucuba*. A small, few-celled nucellar cap persists for a time after fertilization—this cap being larger in the case of developing sterile ovules.

The chalazal region or stalk of the nucellus keeps pace with general ovular growth by the elongation of its cells. The cell protoplasm becomes highly vacuolate and probably serves to conduct the supplies brought by the, as yet, unbranched bundle to the chalazal region. The haustorial antipodals penetrate a little among these cells and by their absorptive action the embryo-sac receives nourishment. During the development of the megasporangium the investing tissue increases in bulk both by cell-division and increase in size of the cells, the net result of these processes being a greater proportional increase in length over circumference. After fertilization time, the tissues of the congenitally-fused integument and raphe (extra-nucellar tissue) begin to show differentiation into an inner meristematic zone including the internal epidermis and an outer developing passive zone. The two tissues, which are at first practically indistinguishable from one another, become more and more distinct as the young seed grows. The expansion of the narrow cylinder of meristem, increasing in size mainly by cell-division in transverse or obliquely transverse planes, correlated with the passive character of the cortical cells, causes continual increase in length over girth during cell enlargement, so that the ovule becomes almond-shaped. That the directive force is exerted axially downwards is clearly shown by the fact that previously transverse cortical rows arch downwards as if they had been drawn down towards the axial cylinder. The shape of the individual cortical cells is, therefore, more or less irregular and attenuated. During growth the vascular bundle of the raphe branches considerably, the system remaining just within the

epidermis and not penetrating inwards: the branches are claw-like and the fine capillaries end in the abraphal side and are not localized in the chalazal region of the seed. The cells of the outer zone change in structure during development by various wall modifications: those of the external epidermis possess a thin outer cuticular membrane and their radial walls become gradually covered with fine, roughly parallel, radial striæ. The walls of the subjacent cells become marked with numerous elliptic pits or are striated. The cortical system is associated with an elaborate peripheral vascular system, and consists externally of cells unoccupied with solid food material, which possess pitted and striated walls, and internally of smaller cells with denser protoplasmic contents. It thus forms an efficient water-jacket with collecting-cells ending against the internal epidermis during the development of a definite endosperm tissue.

The terms "tapetum," used by Billings * and Balicka-Iwanovska †, and "epithelial layer" used by Ducamp ‡ and others imply certain physiological functions, and Billings uses the term tapetum in a purely physiological sense. It seems better in this paper to use the expression "internal epidermis" and to ascribe to it a particular function. The cells of the internal epidermis are distinguished from their fellows by their shape, small size, and denser staining properties of their contents. These properties are shared somewhat by the immediately subjacent cells. Soon after fertilization time the inner wall of the internal epidermis is limited by a fine cutinous membrane, which is easily distinguished when the endosperm is already some cells in diameter. The cellulose portion of this inner wall is minutely perforate. The use of sulphuric acid and iodine shows that the protoplasmic threads of the endosperm and of the internal epidermis end up against the cutin. In *Aralia*, according to Ducamp, the "assise épithéliale" (internal epidermis) and the embryo-sac are shut off from one another by a cutinous membrane. Concerning this layer he states: "Elle s'isole d'ailleurs du sac embryonnaire en cutinesant sa surface et ses parois latérales"; and "le sac embryonnaire et protégé par une laure isolante de cutine contre l'action digestive des cellules épithéliales." The mere presence of a cutinous membrane is insufficient to disprove translocation of liquid. In the case of gaseous and liquid diffusion between two adjacent cell-layers, the inhibitive factor is one of relative thickness of the intervening membrane, since we are dealing with a problem of increased resistance to "flow" dependent upon length and diameter of the membrane passages. The formation of cutin does not necessarily involve the loss of function of the "connecting threads," but the relative thickness of such a membrane may act as a kind of regulator during development, a certain maximum thickness in given cases inhibiting translocation.

The occurrence of antipodal haustoria in certain ovules might lead to the belief that nutriment is passed into the sac at the chalazal end, but it must be borne in mind that the haustoria have only been found in connection with sterile organs. The seeds in which pro-embryos were found show no indication of the presence of persistent antipodals.

* Billings in 'Flora,' 1901, pp. 254 &c. † Balicka-Iwanovska in 'Flora,' 1899, pp. 47 &c.

‡ Ducamp in Ann. Sci. Nat., Bot. sér. 8, xv. (1902) pp. 311-402, tt. 6-13.

The antipodals disappear with the elaboration of the vascular system of the seed—when the conditions are different—and the endosperm is nourished uniformly just as the embryo in its turn is nourished within the endosperm.

It would appear that the endosperm is a walled tissue *ab initio*. This is so in an eight-celled endosperm of *Sambucus* and in slightly older stages of *Cornus* and *Davidia*. In a four-celled pro-embryo stage of *Davidia* the sac is filled fairly uniformly with meristematic endosperm tissue—the pro-embryo being terminal. The pro-embryo is gradually displaced from its terminal position by the elongation of the sac and a corresponding encroachment of the endosperm, which soon, in this part of the sac, becomes more compact than in the main portion of more actively meristematic cells. The endosperm cells of *Davidia*, *Cornus*, and the Caprifoliaceæ are very similar in appearance: the nucleus is fairly large and contains four or five prominent nucleoli, and it is embedded in a vacuolate cytoplasmic sac. The cells are irregular in outline, owing to intermittent division during elongation of the sac, and the cell-walls are thin. As time goes on a compact tissue is formed which sooner or later becomes packed with reserve food.

The youngest primary embryo observed consisted of four cells formed by a transverse and a longitudinal division (Pl. 31. fig. 25). A short suspensor, some four cells in section, was observed in a ten-celled pro-embryo (Pl. 31. fig. 26). The primary embryos are distinguishable *en masse* from endosperm tissue in being slightly more compact; also the cells stain slightly darker and the nuclei are a little larger. The proximal endosperm cells, however, are frequently closely adpressed to those of the primary embryo and take a slightly darker stain than the subproximal endosperm. It is on this account difficult to distinguish between the two tissues. As the suspensor grows longer, the true embryo begins to develop as a small undifferentiated mass of cells. At the same time the basal cells of the suspensor disintegrate, leaving a bulbous cavity in the endosperm (Pl. 31. fig. 27). These basal cells clearly function as an absorbent organ as in the analogous case of the Alsinoideæ described by Gibbs*. By the time they have disappeared the environment of the primary embryo has changed; the surrounding endosperm cells are relatively passive in so far as nuclear division is concerned and are in intimate contact with the suspensor and embryo. After a time the embryo begins to take upon itself the absorptive function of the suspensor.

At the time when the primary embryo consists of some fifty or sixty cells the middle region of the extra-nucellar tissue shows signs of degeneration. The gap in my material between this stage and that of the fully developed fruit prevents me from giving a complete account of the developmental and nutritive processes. A much later stage in *Benthamia*, however, in which the fully stored endosperm does not appear to have been appreciably attacked, leads me to the opinion that the outer region with its peripheral vascular supply persists until the endosperm is organized as a storage tissue.

The fruit at the time of germination consists of an exceedingly hard stony endocarp formed by the sclerosis of all the ovarian tissue within and including that of the inner ring of vascular bundles. It is very difficult to remove the seeds from the endocarp, since

* Gibbs in Ann. Bot. xxi. (1907) p. 40.

they are firmly wedged in the loculi. Dehiscence takes place by the removal of the upper part of the back of each loculus. The seeds before dehiscence are about three-quarters of an inch long and are enveloped in a brownish, scaly testa, which is all that remains of the extra-nucellar tissue of the ovule, and consists of crushed and broken cell-walls with remains of vascular bundles. The endosperm is absorbed by the embryo uniformly by means of its limiting layer of cells, which at the time functions as an epithelium: the endosperm cells adjacent to it are crushed and disorganized. After dehiscence, the radicle bursts through the endosperm at the micropylar end and the seeds germinate while still fixed in the fruit as described by Hemsley *.

7. Discussion of Affinities.

There are three groups of plants near *Davidia*, possessing flowers with multiseriate stamens: 1, *Nyssa* and *Alangium*, outlying forms of admittedly Araliacean affinity among the Cornaceæ; 2, the Scheffleræ; 3, many genera of the Combretaceæ, to which order *Davidia* was provisionally referred by Baillon. The supposed resemblance of Lindley's Alangiaceæ to the Combretaceæ is due to Baillon's ingenious but fallacious argument for the derivation of bi-chambered from unilocular Alangiums by the centripetal advance of parietal placentæ. Baillon † states that at one time the Combretaceæ were thought to comprise plants with ovules inserted near the summit of the ovary, and later it was seen that their placentæ were parietal and centripetal. Imagine the latter to advance further, and we have an ovary with two cells, incomplete or complete, as sometimes observed in *Nyssa* and in the bicarpellary Alangieæ. In *Nyssa*, however, the process is precisely the reverse of that described by Baillon. The occasional presence of a rudimentary style and of an incomplete additional chamber, together with the variable position of the single style, are facts pointing to progressive reduction. If this be so in *Nyssa*, the case could hardly differ in the Alangieæ, where we have two-chambered (*Marlea*) or incompletely two-chambered ovaries (*Alangium*). It was on this point that Baillon referred *Nyssa* and *Alangium* to the Combretaceæ rather than to the Araliaceæ. He considered their affinity to either of these orders greater than their affinity to the Cornaceæ.

The ovary of *Davidia* presents certain general resemblances to that of *Aralia*, notably in possessing a distinct ovarian vascular system and one-seeded chambers—the seeds in both cases resting radially in the loculus with the vascular bundle between the nucellus and axis. The ovaries of both genera are inferior, but the degree of epigyny in *Davidia* is greater than it is in *Aralia*, and associated with this the carpellary system of the former is more concentrated. The two forms are in nearly equivalent evolutionary phases. There are, however, important differences both in the mode of suspension and vascular connection of the ovule. To make this point clear let us turn for a moment to the Caprifoliaceæ. The ovaries of *Leycesteria* and *Lonicera* are pluriovular, the ovules being arranged in biseriate rows in the chambers. The lower ovules of the

* Hemsley in Journ. Linn. Soc., Bot. xxxv. (1903) p. 556.

† Baillon, Hist. Pl. vi. p. 271.

biseriate rows are inserted axially and the upper on free placentæ. In *Lonicera Caprifolium* a number of ovules may abort and there is often but one seed, which occupies eventually the single chamber enclosed by the uniformly expanding ovary wall. In *Symphoricarpus* the lower portion of the ovary is four-chambered, the lateral loculi containing each a single ovule axially attached towards the upper end of the ovary and tangentially situated—raphe abaxial and lateral. Immediately inferior and at right angles to these ovules, two more are situated, also axially borne. These are the lowermost ovules of the "anterior and posterior" loculi, and they are directed towards the floor of the chamber, where their position is, in some cases at least, radial—raphe abaxial. Above the insertion of these ovules the ovary is two-chambered, the chambers being the superior portions of the multiovular loculi. The ovules are here borne biseriately on free placentæ. In *Viburnum Lantana* two chambers are rudimentary and contain biseriate rudimentary ovules, the third is uniovular. In *Sambucus* there is a single ovule suspended axially and in the superior portion the merest rudiments of ovules in each chamber. There is no doubt, therefore, that the ovaries of ancestral forms of both *Viburnum* and *Sambucus* were pluriovular with ovules arranged in series as in *Leycesteria*. In the chambers of *Symphoricarpus* which contain a single seed the vascular connection of the ovule is similar to that of a pair of ovules when they are arranged in biseriate rows—*i. e.*, two strands join in the raphe to make the single main ovular bundle. A similar condition obtains in *Sambucus* and *Davidia*. The chambers of the ovaries of certain Araliacean genera contain each a fertile and a rudimentary ovule; these are suspended from the upper part of the ovary and receive each a single vascular bundle. If, therefore, the ancestral forms of *Davidia* and *Aralia* possessed pluriovular ovaries, the ovaries of both genera would appear to have evolved along different lines from that condition.

With regard to the Nyssas, Baillon * states that the male flowers possess an equal (double, triple, or quadruple) number of stamens, arranged in verticels, while in the hermaphrodite flower the andrœcium is the same. Sargent † states that the stamens in the male flower are five or indefinite, and in the pistillate flowers five to ten or wanting. The arrangement in series is by no means regular. The flower of *Nyssa* differs chiefly from that of *Davidia* in that the ovary is reduced to a single uniovular chamber, is surmounted by a disc, and possesses free styles. The flowers of *Alangium* vary from tetracyclic to heptacyclic according to the number of whorls, which are tetramerous to decamerous (with the exception of the one-, two-, or three-chambered ovary), the style is almost entire or divided into a number of small lobes. *Davidia* differs from *Alangium* in possessing apetalous, polygamous flowers, while an epigynous disc is absent from the ovary.

The ovules of the Araliaceæ lie radially in the loculus, the raphe being adjacent to the placenta—the typical ventral ovule of a number of authors: those of the true Cornels have long been characterized as possessing dorsal raphes. Attempts to sort out ovules

* Baillon, Hist. Pl. vi. p. 267.

† Sargent, Silva N. America, v. p. 73.

upon these lines, especially in the case of uniovular ovaries, have caused considerable confusion. For example, Baillon states that in *Eustigma oblongifolium* "the raphe is *at first dorsal*, but owing to a partial torsion the micropyle is brought to one side," and that in *Fothergilla alnifolia* the ovule is "twisted as in *Hamamelis* with its superior micropyle on one side—*at first ventral*." Again, if we examine the nucellus of *Aucuba* we find that it is situated obliquely at early stages, attaining ultimately the dorsal position; while in the case of a biovular ovary the ovules rest tangentially in the chamber. The ovules of *Symphoricarpus* are similarly situated except the lowermost ones of the pluriovular chambers, which may take up the dorsal position. Ducamp has shown that the lateral preceeds the ventral condition in the Araliaceæ, and that the nucellus of *Hedera*, at least, is ontogenetically lateral. The mode of development of the incomplete integument of *Davidia* and the position of the micropyle in young ovules brings this genus into line with the former. The use of the terms ventral and dorsal is obviously two-fold. In some natural orders the position of the micropyle is a useful criterion in distinguishing two forms of ovule, as, for instance, in the Rosaceæ. It does not follow, however, that it is serviceable when more generally employed. In a similar way, the terms ascending and descending may be employed within a limited range.

A great deal of confusion has been caused in connection with the set of ovules under consideration, by supposing the "dorsal" ovule to possess an inwardly directed micropyle, and the "ventral" ovule an outwardly directed micropyle. As a matter of fact, the micropyle in both types of ovule may be lateral. The lateral micropyle in no wise indicates that we are dealing with *ovules of an intermediate character*, as suggested by Harms *. The micropyle is in these cases of subordinate value as a criterion. There seem to be two distinct forms of ovule, at least, which have evolved along independent lines. The fundamental points of difference are difficult to set down, and can only be grasped by a comparative study of ovular development. The differences may, to a certain extent, be expressed by the position taken up by the ovule in the loculus. There exists, on the one hand, a tendency towards a radial position at maturity, so that the vascular bundle of the raphe lies between the nucellus and placenta (*Aralia*); and, on the other hand, towards a tangential position at maturity. Under certain circumstances of sterilization the tangential position changes to the radial, only in this case the respective positions of vascular bundle and nucellus are interchanged (*Aucuba*). The above considerations lessen the logical value of the remarks made by Harms (*l. c.*) in his discussion of the affinities of Cornaceæ in 1897.

The ovule of *Davidia* is similar to that found in *Nyssa* and *Alangium* and in the Araliaceæ—a natural order characterized by the possession of the "ventral" ovule—while it differs very considerably from that of the Cornoideæ. *Davidia* is strongly marked off from the Hamamelidaceæ in that the latter possess two integuments and a bulky nucellus. The nucellus of *Davidia* resembles that of *Cornus* in bulk, a resemblance which may be regarded as indicating that the two forms in question are in an equivalent evolutionary phase rather than as affording evidence of affinity.

* Harms in Ber. Deuts. Bot. Gesell. xv. (1897) pp. 21–29.

The occurrence of a multicellular archesporium in *Davidia* is probably not to be regarded as primitive. Lloyd * states that in the Rubiaceæ the archesporium contains 7–15 megaspore-mother-cells, the largest number occurring in species of the Galieæ. Each mother-cell, with the exception of the arrested ones at the side of the archesporium, divides to form four megaspores, which, except very infrequently, are not separated by walls. He considers this the result of specialization. The condition obtaining in the Galieæ is simulated by the sterile megasporangia of certain genera of the Caprifoliaceæ. In the sterile ovules of *Symphoricarpus* there is generally a single archesporial cell giving rise to four megaspores which are not arranged in a linear row. One of these germinates and produces an incomplete embryo-sac. The incomplete ovules of *Viburnum Lantana* are little more than stalked nucelli. The sporogenous tissue may arise from one or more subepidermal cells which are megaspore-mother-cells, and may give rise to megaspore groups of four (in the fertile ovules the arrangement of the megaspores is linear). Each group of megaspores gives rise to a number of nuclei (generally an even number), which are arranged in hollow, sometimes segmented protoplasmic sacs. The condition of these sterile megasporangia recalls the anomalous structures which have been observed in *Peperomia* and *Gunnera*. In *Sambucus nigra* ovular abortion has culminated in the production of the merest rudiments. These are found in the superior portion of the ovary towards the base of the stylar canal. Each one consists of a subepidermal layer of cells apparently of an archesporial nature. These cells divide to form groups of four without the formation of cell-walls. The ovular rudiments in *Sambucus* afford the last traces of ovules phylogenetically dead. The multicellular archesporium of *Davidia* might therefore be regarded as a development correlated with the abortion of ovules upon somewhat different lines.

The Araliaceæ, Cornaceæ, and *Davidia* possess the following characters in common:—(1) epigynous flowers; (2) ovaries with one-seeded chambers; (3) ovules with a single incomplete integument; (4) small nucellus; (5) endosperm. The ovaries of many genera of Cornaceæ are uniovular. It has been pointed out that this condition has been attained in the Caprifoliaceæ by progressive abortion—the different genera proceeding towards the uniovular condition along different lines. Hence the uniovular condition, whether it refers to the ovary or loculus, should not receive too much weight in establishing mutual relationships; at the same time, characters of apparently minor importance may serve to indicate a particular line of development, and on that account prove of value. Thus the terminal ovules of *Davidia* and the Araliaceæ have had a different origin. The form of ovule regarded in a similar manner becomes of fundamental importance, and serves to emphasize the gap between the Cornoideæ and the genera of Cornaceæ possessing the Aralian form of ovule. *Davidia*, therefore, stands apart from the Cornoideæ, and is allied rather with the Araliaceæ, the Nysseæ, and the Alangieæ. The manner in which the terminal ovule is suspended separates *Davidia* from the Araliaceæ. Taking all the factors into account, the nearest resemblance is to the Nysseæ and Alangieæ. The ovaries of these forms show evidence of having been

* F. E. Lloyd in Mem. Torr. Bot. Club, viii (1902) pp. 27–111.

derived from plurilocular ovaries, containing in each loculus, we may suppose, a single ovule of the Aralian form. At the same time, the organization and structural detail of the inflorescence and flower of *Davidia* are peculiar, and do not indicate *close* affinity with *Nyssa* and *Alangium*. The genus occupies a somewhat isolated position, and may be regarded as having evolved along independent lines from the plexus of primitive groups which included the ancestral forms of Araliaceæ, Nysseæ, and Alangieæ.

SUMMARY.

1. The vascular structure of the hypocotyl varies considerably.
2. The inflorescence consists of a number of congenitally-fused, apetalous, multistaminate male flowers: or of male flowers and, in addition, a single obliquely-situated, apetalous hermaphrodite flower with epigynous stamens *arranged in series*. The arrangement in series is suggested on account of the vascular attachment of as many oppositilocular stamens as there are loculi to the ovarian cylinder of bundles.
3. The insertion of the bract-trace takes place above the point of insertion of the bracts themselves, and sometimes as high up as the torus. There are, therefore, three vascular "bundles" on each side of the axial cylinder in the peduncle above the insertion of the bracts.
4. The ovules in the multilocular ovary—seven being the mean number of loculi—are attached axially, one in each chamber, and unaccompanied by a rudimentary ovule: correlated with this the vascular bundle in the raphe is made up of two bundles, one from each adjacent septum, joined together, and not of a single bundle from an adjacent placenta, as is frequently the case in the Araliaceæ and Umbelliferæ.
5. The ovule is of the Aralian type, only more specialized, possessing a single, very incomplete integument, which grows up leaving the micropyle on one side or the other.
6. The nucellus is of small bulk and comparable to the nucelli of *Cornus* and *Aralia*. It does not persist.
7. The sporogenous tissue usually gives rise to more than one embryo-sac, of which only one develops to any extent. A number of abnormalities occur in the number, arrangement, and form of the embryo-sac nuclei. The functional embryo-sac of the only fertile ovule observed was perfectly normal. Sterilization processes in the Caprifoliaceæ are accompanied by abnormal nuclear phenomena in the embryo-sacs of sterile ovules (*Symphoricarpus*), and by the presence of a multicellular archesporium in the nucelli of incomplete ovules (*Viburnum*). In the Rubiaceæ highly specialized ovules are associated with a multicellular archesporium. Under the circumstances no primitive significance is attached to the condition of the archesporium in *Davidia*.
8. After fertilization time, the tissues of the congenitally-fused integument and raphe (extra-nucellar tissue) differentiate into an inner meristematic zone including the secretory epithelium (internal epidermis), and an outer non-meristematic

zone. The expansion of the narrow cylinder of meristem, increasing in size mainly by cell-division in transverse or obliquely transverse planes, causes considerable increase in length over girth during cell-enlargement, and has a dragging effect on the non-meristematic cells, so that previously transverse cortical rows arch downwards as if they had been drawn down toward the axial cylinder, and the seed becomes almond-shaped. The vascular bundle branches considerably; the fine capillaries, which do not penetrate inward, end in the abraphal side.

9. During the development of the primary embryo the old antipodal system disappears. The cells of the internal epidermis are organized into a definite epithelium which forms a means for supplying the sac uniformly with nutritive material, after the manner described by Billings for the Caprifoliaceæ. The extra-nucellar tissue forms a kind of water-jacket, the inner cells of which (inner, meristematic zone) function as collecting-cells.

10. True endosperm is present as a thin-walled tissue in very young stages of the primary embryo. Owing to intermittent division of the endosperm cells and the general elongation of the sac, the outline of the cells is irregular.

11. The upper cells of the young pro-embryo function as a temporary absorbent organ, leaving a bulbous cavity in the endosperm when they disappear. By this time the true embryo begins to develop at the end of the suspensor as a small undifferentiated mass of cells, and later takes upon itself the absorptive function of the suspensor.

12. The fruit at the time of germination consists of an exceedingly hard stony endocarp formed by the extreme sclerosis of all the ovarian tissue within, and including that of the inner peripheral cylinder of bundles. Dehiscence takes place by the removal of the upper part of the back of each chamber. The seeds are enveloped in a brown, scaly testa, which is all that remains of the extra-nucellar tissue.

13. The embryo gradually absorbs the endosperm by means of its epidermal layer, which, at the time, functions as a secretory epithelium. During germination the radicle emerges from the endosperm in the manner described by Hemsley.

14. From a detailed study of the flowers, ovary, ovule, and seed, the author is inclined to believe that *Davidia* has no real affinity with the Hamamelidaceæ, but is distantly related to *Alangium* and *Nyssa*, and still more distantly related to the Araliaceæ: that the genus occupies a more isolated position than has hitherto been supposed, owing to having pursued an independent course of development from the plexus of primitive groups which included the ancestral forms of the Araliaceæ, Nysseæ, and Alangieæ.

I desire to express my heartfelt thanks to Professor J. B. Farmer for having placed his material of *Davidia* at my disposal for the purposes of this research, and for his continual help and encouragement.

Bibliography.

Baillon, H. Sur deux nouveaux genres apétales. Adansonia, x. (1871–1873) pp. 112–117.

—— Histoire des Plantes, vi. p. 282. Paris, 1877.

David, Armand. Nouv. Arch. du Mus. Par. v. (1882).

Decaisne, J., et E. Le Maout. Traité Général de Botanique, 1868.

—— A General System of Botany. Translated by Mrs. Hooker, 1873.

Ducamp, L. Recherches sur l'embryogénie des Araliacées. Ann. Sc. Nat., Bot. sér. 8, xv., xvi. (1902).

Franchet, A. Plantæ Davidianæ ex sinarum imperio. I. Nouv. Arch. Mus. Par. sér. ii. t. v.–vi. (1884).

—— Plantæ Davidianæ. II. Plantes du Thibet oriental (province de Moupine). Nouv. Arch. Mus. Par. t. viii.–x. pl. 10 (1888).

Harms, H. Die Gattungen der Cornaceen. Ber. Deuts. Bot. Gesell. Band xv. (1897) pp. 21–29.

—— Engler u. Prantl, Nat. Pfl., Teil iii. Abt. 8, pp. 250–270 (1908).

Hemsley, W. Botting. On the Germination of the Seeds of *Davidia involucrata*, Baill. Journ. Linn. Soc., Bot. vol. xxxv. (1903) p. 556.

Lloyd, F. E. The Comparative Embryology of the Rubiaceæ. Mem. Torr. Bot. Club, viii. (1899–1902) pp. 1–112.

Oliver, D. Hooker's Ic. Pl. t. 1961 (1891).

Sertorius, A. Beiträge zur Kenntniss der Anatomie der Cornaceæ. Diss., München, 1893, and in Bull. Herb. Boiss. vol. i. (1893).

Wangerin, Walther. Die Umgrenzung und Gliederung der Cornaceæ. Engl. Bot. Jahrb. xxxviii. (1906) pp. 1–88.

EXPLANATION OF THE PLATES.

Abbreviations.—*ant.* = antipodals ; *e.sac* = embryo-sac ; *en.* = endocarp ; *end.* = endosperm ; *i.ep.* = internal epidermis ; *int.* = integument ; *m.sp.* = megaspore ; *m.sp.m.c.* = megaspore-mother-cell ; *nu.ep.* = epidermis of nucellus ; *nu.cap* = nucellar cap ; *oos.* = oosphere ; *pro-emb.* = pro-embryo ; *sus.* = suspensor ; *syn.* = synergids ; A = central cylinder in transverse section.

Plate 31.

Fig. 1. Young inflorescence (enlarged).

Figs. 2–4. Stages in the development of the hermaphrodite flower (enlarged).

Figs. 5–12. Stages in the development of the fruit (5 & 6 enlarged ; 7–12 nat. size).

Fig. 13. Seeds.

Figs. 14–17. Stages in the development of the sporogenous tissue. × 600.

Figs. 18, 19, 21. Development of more than one megaspore. × 600.

Figs. 20, 22, 24. Abnormal embryo-sacs. × 600.

Fig. 23. Embryo-sac just prior to fertilization. × 600.

Fig. 25. Two cells of four-celled pro-embryo. × 600.

Figs. 26, 27. Later stages in the development of the pro-embryo. × 600.

Plate 32.

Figs. 1–8. Vascular structure of the seedling of *Davidia involucrata.*

Fig. 9. See pages 305 and 306.

Fig. 10. Variation in the hermaphrodite flower of *Davidia involucrata* : 5–10, number of loculi ; 15–27, number of stamens.

Fig. 11. Variation in the male flower of the same : 2–30, number of groups; 2–10 (bottom), number of stamens in group.

Fig. 12. Variation in the flower of *Hedera Helix* var. *arborea* : 4–9, number of stamens ; 1–7 (bottom), number of loculi.

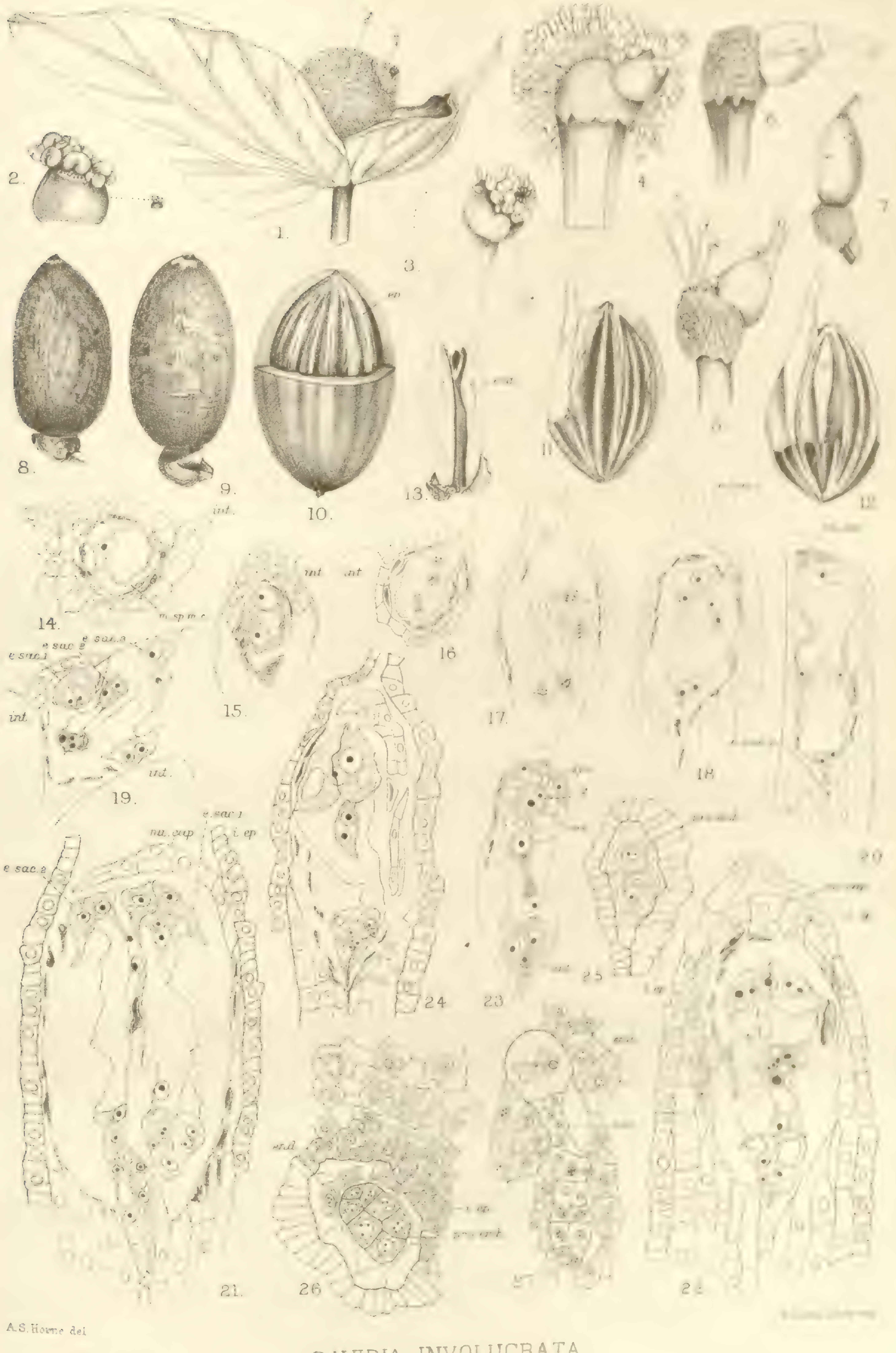
Plate 33.

Figs. 1–14. Diagrams illustrating the vascular structure of the inflorescence of *Davidia involucrata.*

Figs. 15, 16. Diagrams to illustrate the vascular structure of congenitally-fused branchlets of the inflorescence of *Viburnum stellulatum* (15, two vascular cylinders in transverse section ; 16, a single vascular cylinder).

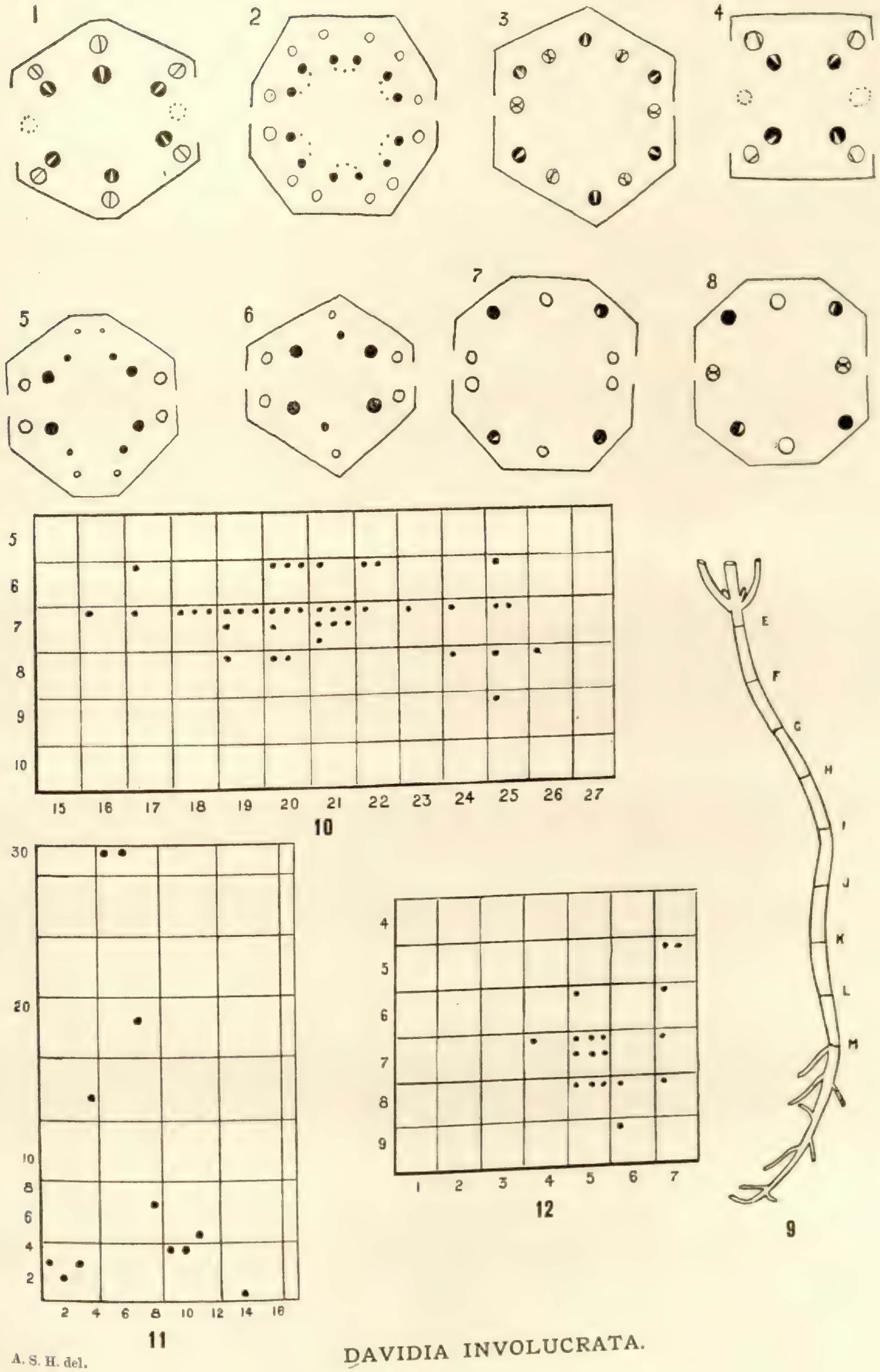
Fig. 17. Diagram of a transverse section to illustrate the vascular structure of the common stalk (peduncle) of the congenitally-fused inflorescence of *Prunus serrulata.*

Note.—Figure 1 has been accidentally drawn upside down.



A. S. Horne del.

DAVIDIA INVOLUCRATA.



A. S. H. del.

DAVIDIA INVOLUCRATA.

A. S. H. del.

DAVIDIA INVOLUCRATA.

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s*. to the public, and 6*s*. to Fellows; to Vols. 26–30, 4*s*. to the public, and 3*s*. to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

SECOND SERIES.—BOTANY.

Volume.	Part	When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
I.	Parts I.–IX. (complete).	1875–80.	8	1	0	6	1	0
II.	Part I.	1881.	0	12	0	0	9	0
	Part II.	1882.	0	5	0	0	3	9
	Part III.	1883.	0	10	0	0	7	6
	Part IV.	1883.	0	3	0	0	2	3
	Part V.	1883.	0	3	0	0	2	3
	Part VI.	1884.	0	13	6	0	10	0
	Part VII.	1884.	0	9	6	0	7	0
	Part VIII.	1884.	0	10	0	0	7	6
	Part IX.	1886.	0	7	0	0	5	0
	Part X.	1887.	0	3	4	0	2	6
	Part XI.	1886.	0	6	0	0	4	6
	Part XII.	1886.	0	8	0	0	6	0
	Part XIII.	1887.	1	7	0	1	0	0
	Part XIV.	1887.	0	7	0	0	5	0
	Part XV.	1887.	0	10	0	0	7	6
	Part XVI.	1888.	0	2	6	0	2	0
III.	Part I.	1888.	3	12	0	2	14	0
	Part II.	1891.	0	5	0	0	3	9
	Part III.	1891.	0	7	0	0	5	0
	Part IV.	1891.	0	6	0	0	4	6
	Part V.	1891.	0	6	0	0	4	6
	Part VI.	1891.	0	3	6	0	2	8
	Part VII.	1892.	0	6	0	0	4	6
	Part VIII.	1893.	0	6	0	0	4	6
	Part IX.	1893.	1	8	0	1	1	0
	Part X.	1894.	0	10	0	0	7	6
	Part XI.	1894.	0	3	4	0	2	6
IV.	Part I.	1894.	1	0	0	0	15	0
	Part II.	1894.	2	0	0	1	10	0
	Part III.	1895.	2	10	0	1	17	0
	Part IV.	1895.	0	3	4	0	2	6
V.	Part I.	1895.	0	9	0	0	6	9
	Part II.	1895.	0	12	0	0	9	0
	Part III.	1896.	0	6	0	0	4	6
	Part IV.	1896.	1	0	0	0	15	0

SECOND SERIES.—BOTANY (*continued*).

Volume.	Part	When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
V.	Part V.	1896.	0	14	0	0	10	6
	Part VI.	1896.	0	4	0	0	3	0
	Part VII.	1897.	0	4	0	0	3	0
	Part VIII.	1897.	0	6	0	0	4	6
	Part IX.	1899.	0	12	0	0	9	0
	Part X.	1899.	0	6	0	0	4	6
	Part XI.	1899.	0	7	0	0	5	0
	Part XII.	1899.	0	12	0	0	9	0
	Part XIII.	1900.	0	1	6	0	1	2
	Part XIV.	1900.	0	3	0	0	2	3
	Part XV.	1901.	0	6	0	0	4	6
VI.	Part I.	1901.	1	10	0	1	2	6
	Part II.	1901.	0	6	0	0	4	6
	Part III.	1902.	0	18	0	0	13	6
	Part IV.	1903.	0	8	0	0	6	0
	Part V.	1903.	0	8	0	0	6	0
	Part VI.	1903.	0	12	0	0	9	0
	Part VII.	1904.	0	12	0	0	9	0
	Part VIII.	1904.	0	12	0	0	9	0
	Part IX.	1904.	0	7	0	0	5	3
	Part X.	1904.	0	14	0	0	10	6
	Part XI.	1905.	0	4	0	0	3	0
VII.	Part I.	1904.	0	5	0	0	3	9
	Part II.	1905.	0	6	0	0	4	6
	Part III.	1906.	0	3	0	0	2	3
	Part IV.	1906.	0	7	0	0	5	3
	Part V.	1907.	0	10	0	0	7	6
	Part VI.	1907.	0	4	0	0	3	0
	Part VII.	1907.	0	6	0	0	4	6
	Part VIII.	1908.	0	5	0	0	3	9
	Part IX.	1908.	0	2	6	0	2	0
	Part X.	1908.	0	7	0	0	5	3
	Part XI.	1909.	0	4	0	0	3	0
	Part XII.	1909.	0	12	0	0	9	0
	Part XIII.	1909.	0	5	0	0	3	9
	Part XIV.	1909.	0	6	0	0	4	[illegible]

2nd Ser. BOTANY.] [VOL. VII. PART 15.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

THE ANATOMY OF WELWITSCHIA MIRABILIS, Hook. f., IN THE SEEDLING AND ADULT STATES.

BY

M. G. SYKES, Girton College,
FELLOW OF NEWNHAM COLLEGE, CAMBRIDGE.

(*Communicated by* Prof. H. H. W. Pearson, Sc.D., F.L.S.)

LONDON:

PRINTED FOR THE LINNEAN SOCIETY
BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.
SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,
AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

October 1910.

XV. *The Anatomy of* Welwitschia mirabilis, *Hook. f., in the Seedling and Adult States. Forming Report No. 2 of the Percy Sladen Memorial Expedition to South-West Africa*, 1908–1909.

By M. G. Sykes, *Girton College, Fellow of Newnham College, Cambridge.* (*Communicated by* Prof. H. H. W. Pearson, *Sc.D., F.L.S.*)

(Plates 34 & 35 and 5 Text-figures.)

Read 21st April, 1910.

Contents.

		Page
Introductory		327
Section I.	Development of Outward Form	328
II.	The Root System	334
III.	The Structure of the Ridges and Young Inflorescences	337
IV.	The Cotyledonary Buds (Lobes of the Crown)	339
V.	Transition Phenomena	340
VI.	Comparison of the Transition Phenomena with those in other Gymnosperms	344
VII.	Centripetal Xylem in the Seedling	346
VIII.	Anatomy of the Adult Hypocotyledonary Stem	347
IX.	General Conclusions	348

Although the structure of this interesting and isolated genus has already been investigated by various workers *, it seemed advisable that it should be further studied in the light of recent research. A large number of seedlings and young plants (collected and preserved during the recent Percy Sladen Memorial Expedition in South-West Africa) have been most kindly placed at my disposal by Professor Pearson. In addition to these, I have examined two younger seedlings grown in the Cambridge Botanic Garden.

The investigation of this material, while confirming the greater part of the account of the seedling anatomy given by Bower † in 1881, has also brought to light additional points of interest, which appear to be of some importance. In addition to the description of the facts contained in that memoir, this paper includes short discussions of theoretical questions on which evidence is obtained from a study of the mode of growth and the structure in *Welwitschia*, and an attempt has been made to draw attention to such characteristics in the structure of this plant as are of especial interest in connection with recent work.

I am indebted to Professor Pearson for his kind interest in this paper, and to Mr. D. Thoday for valuable assistance in the preparation of the text-figures.

* Hooker, 1863; Bower, 1881; de Bary, 1884, &c.

† Bower, F. O., 1881, I. & II.

Section I.—Development of Outward Form.

The earliest stages in the formation of the seedling from the embryo have been described by Bower *; and in his later paper he gives a very clear account of the method of growth in older seedlings. I have, however, been fortunate enough to obtain plants of apparently intermediate age which have furnished some further points of considerable interest.

Stage 1.—Pl. **34.** fig. 1 shows a seedling about thirteen months old. Its cotyledons are still attached and the feeder inserted in the husk of the seed. The hypocotyl is as yet fairly uniform in thickness, save for a slight swelling at S. The bases of the cotyledons are continuous, and at each of the two points where the margins of the bases join occurs a small swelling (R) †, which, since it appears to have passed unnoticed by earlier observers, is possibly unusually prominent in this seedling. The two plumular leaves are already well developed, and, alternating with the cotyledons, are attached within the ridge formed by the fused cotyledonary bases. The stem apex is as yet only slightly depressed, and is so little differentiated as to be hardly distinguishable: on either side of the apex occurs a small conical process, which, on account of its position, is to be regarded as a bud borne in the axil of the cotyledon ‡.

At this stage the cotyledons are green and living, but their bases are mainly composed of corky cells similar to those found on the exterior of the stem. In seedlings representing stages intermediate between those shown in figs. 1 and 2 examined from time to time while growing at the Botanic Garden, it was seen that the steadily broadening plumular leaves pressed against the bases of the cotyledons, and, some time before the latter began to wither, caused a split to appear in the region of pressure, whereby the base of the cotyledon became bifurcated.

The cotyledons then gradually dry up and wither away. They have already withered in the seedling shown in Pl. **34.** figs. 2 *a*, 2 *b*; their ragged bases are seen at C (fig. 2 *b*). There is no definite absciss layer formed, but the cotyledons wither and gradually drop off, owing to the slow decay of the tissue at their base; the continuity of the two primary vascular bundles is preserved for a considerable period.

Stage 2.—At this stage the upper portion of the hypocotyl is much swollen and fusiform (Y, fig. 2). In this particular seedling the feeder could no longer be distinguished, but it was still present in the larger seedling drawn in fig. 3; here it is clear that only the upper part of the hypocotyl has swollen. The unswollen portion of the hypocotyl (U, figs. 3 & 4) is usually of considerable length, as in this seedling (fig. 3), but it is occasionally quite short; one case was examined in which its length was somewhat less than that of the swollen portion; and in another example, at about the stage shown in fig. 3, the feeder was placed immediately beneath the swollen

* Bower, I. pp. 15–20.

† It will be seen that there is a special vascular supply to these swellings, a fact which adds to the interest already awakened by their outward appearance (Pl. **35.** figs. 15 *a* & *b*).

‡ Bower, I. and II.; *cf.* also Henriques, J. A., Bot. Centralbl. (1909) no. 47, p. 68.

hypocotyl and no unswollen portion was present (Pl. 34. fig. 6). The meagre development of the hypocotyl in this seedling is probably correlated with the fact that the plumular leaves were not properly grown, and were still contiguous by their upper surfaces, thus reducing assimilation and retarding growth.

The top of the fusiform hypocotyl (Pl. 34, X, fig. 2) is slightly flattened between the ragged remains of the cotyledons, and it is apparent that some intercalary growth must have taken place in this region, separating the once continuous margins of the two cotyledonary bases. The method of growth will be more easily understood on reference to figs. 1 *a* and 3, where the downward sloping scars (C) represent the margins of the bases of the old cotyledons, now separated from one another by a further growth between the cotyledons, resulting in the formation of a more or less triangular portion (T). It will be seen that this intercalary growth has taken place just below the swellings (R) shown in fig. 1; by means of the upward and lateral growth of these swellings a still more noticeable change has taken place, resulting in the development of a very definite and swollen ridge continuous round the top of the enlarged hypocotyl. From an examination of the intermediate stages referred to (figs. 1 *a* & 3) it is clear that the accelerated meristematic growth which first began in the swellings (R) has afterwards spread from these swellings round the projecting edge left after the withering of the cotyledons, until it forms two elongated ridges which finally fuse in the median plane of the cotyledons so as to form a continuous ridge. In fig. 2 a small indentation, at each of the two ends of the ridge, is the only sign of its double origin. In many of the older seedlings it is found that even this has disappeared (see also O, fig. 9 *a*).

Consequent on the upgrowth of this narrow ridge and immediately internal to it there is a groove, already of some depth, from the base of which spring the two plumular leaves. Between the leaves on their inner side is the depressed apex, which remains inactive. On either side of the apex the conical processes, or cotyledonary buds, have become considerably enlarged (Pl. 34, B, fig. 2); they are much elongated in a plane at right angles to the planes of the two cotyledons, a fact which makes their appearance unlike that commonly distinctive of buds, but which is probably to be attributed to the effect of lateral pressure, exerted on them during their development by the closely appressed plumular leaves.

Stage 3.—In fig. 4 *b* it will be seen that the upper part of the fusiform hypocotyl has become further swollen, so that it is now globular (K). A few seedlings of this age, or even older, were observed in which the fusiform shape was retained, but the globular upper portion has been more or less developed in all the mature plants which have been observed. In many seedlings of this stage there is a flattened portion (*cf.* X, fig. 2) intercalated by the continuation of growth between the cotyledonary bases and extending laterally beneath the ridge, but in the seedling shown in fig. 4 there was no definite flattened portion developed. The ridge is now still further enlarged, and by its smooth white appearance is rendered very conspicuous against the rough brown surface of the rest of the hypocotyl. The upward growth of the ridge has deepened the leaf-groove; it is deepest at its ends opposite the original position of the cotyledons, while at the flanks its floor is raised up by the meristematic division continually taking place

at the base of the leaf. On the inner side of the leaf-groove a second prominent white ridge is now to be distinguished, resulting from the intercalation of a second elongated area of meristematic growth, internal to the leaves. This second ridge forms the inner lip of the groove and is shown in fig. 4 *c* (Br.), where it appears as a narrow band encircling three sides of the base of each of the cotyledonary buds: its growth has already raised up the cotyledonary buds above their original level. It is from this inner ridge that the inflorescences commonly arise.

Further Growth.—The general form attained in Stage 3 is but little modified in the mature plant. The method of growth from this stage has been carefully described by Bower. The changes in form are chiefly brought about by cell-divisions at the base of the leaf-groove, by means of which the inner and outer ridges grow in size and become still further raised *.

The uplifting of the cotyledonary buds by the growth and expansion of the inner ridge gives the growing plant a very remarkable appearance. The buds, or lobes of the crown, as they have been called, become much enlarged and flattened, forming the well-known "table-top" so characteristic of old *Welwitschia* plants; they are usually merged in one another on their contiguous sides, the line of fusion (F, fig 9) being often hardly or not at all distinguishable. It is obvious that in these cases the apex of the plant has become buried by the growth of the "crown" and is incapable of further growth.

Pl. 34. fig. 9 represents a young plant which has attained to the mature form. The growth of the cotyledonary buds and the intercalation of the inner ridge has pushed apart the two sides of the leaf-groove, and has consequently separated widely the formerly closely approximated leaves. Both inner and outer ridges still show traces of their double origin (O^1, O^2, fig. 9 *a*).

Origin of the Inflorescences.—The origin of the inflorescences in young and mature plants has been described by Bower † and Pearson ‡. Among my young plants were some very early stages in which only one or two inflorescences had as yet been developed. In each case they were borne on the inner lip of the groove, *i. e.* the inner meristematic ridge, and the first-formed inflorescences always occurred opposite the line separating the two cotyledonary buds, in what appears to be always the oldest portion of the intercalated region (fig. 9). Their formation is generally confined to the inner ridge, but Pearson has recorded as not uncommon cases in which the outer ridge becomes much enlarged and zoned, and gives rise to inflorescences.

Modifications of the Normal Development.—It has been remarked above that in normal cases the apex is buried by the growth of the crown and no further development is possible.

In quite a large number of instances it is found that the *lobes of the crown* are *not merged in one another*, at any rate up to a considerable age. In these cases meristematic growth produces transverse continuations of the inner ridge so that each bud is completely encircled. Fig. 7, although drawn for a different purpose, may, if A be

* Bower, II. pp. 583–585, pl. 33. fig. 10.

† Bower, II. p. 590, figs. 13 & 14; see also Hooker, 1863.

‡ Pearson, II. pp. 332–333.

omitted, be regarded as representing such a case. It is in fact almost duplicate of another plant in which A was not present. It will be seen that in such plants the apex is not buried and might well be able to undergo further development.

Cases have been recorded in which the first pair of leaves remained small and later growth of the apex produced *extra leaves* *.

Fig. 1.

Among my material was only one case, a mature plant (text-fig. 1) †, in which a *single extra leaf* had been produced by an individual otherwise quite normal. This extra leaf takes its origin deep down between two cotyledonary buds, and must have been produced by growth at or near the depressed apex. It decussates with the members of the first pair, but is considerably narrower, and its width is much less than the width of the cotyledonary buds. The cotyledonary buds diverge considerably at the centre, where this leaf originates, but are contiguous on either side of the leaf. The line of fusion between them is even here, however, quite distinct, and it appears that, owing probably to the unusual extra growth at the apex, they remained separate until a late stage.

In one of my young plants (Pl. 34. fig. 7), already referred to as having its two cotyledonary buds remaining unfused, a curious *elongated projection* (A, fig. 7) occurred between the buds in the position occupied by the apex in the young plant. This projecting object was shown by anatomical examination to be in organic continuity with the plant, having its origin between the lobes of the crown, from the apex of the stem; but I do not feel qualified to give any decided opinion as to its morphological nature. It is oval in transverse section, and at its base it is composed of parenchymatous tissue without a vascular supply; higher up the central portion is still parenchymatous, while a number of groups

* C. Naudin, 'The Gardeners' Chronicle,' Aug. 13, 1881 (*ex* Bower, II. p. 593).

† This photograph was taken near Mossamedes by Professor Pearson, who has kindly lent it to me.

of fibres are seen to be developing just internal to the epidermis (Pl. 34. fig. 10 *a*). Higher still these fibres are fully mature (fig. 10 *b*): they are thick-walled unlignified cells, exactly resembling those borne in groups under the epidermis of the leaf in *Welwitschia* and occurring in many other parts of the plant. A few lignified elements occur on the outer edge of some of the groups of fibres, chiefly at the ends of the oval, but it is not possible to affirm that these are of the nature of xylem and they were lignified only for a very short part of their course (fig. 10 *a*, L). The upper part of the object is composed entirely of loose corky cells with suberized walls, and there can be little doubt that it is in a degenerating condition.

It may be that the structure is to be regarded as axial in nature, produced by the further development of the apex itself. I am more inclined to consider it as representing another pair of leaves fused by their contiguous surfaces and never having attained to mature development. This possibility was suggested to me by an examination of the seedling shown in fig. 6, in which the first two plumular leaves were still contiguous by their inner and upper surfaces, and the hypothesis is supported by the presence of regular peripheral groups of fibres, but there is no trace of a double origin *. The parenchymatous nature of the base is probably evidence that it has been added to in that region by meristematic growth, as is the case with the leaves. It would certainly appear that the apex of the structure is older than the base.

A very *remarkable development of one of the leaves* of a young plant is to be seen in fig. 8 *a*, *b*. While one of the leaves was normally developed from the groove on one side of the plant, the other was only partially confined to the groove on the other side. Half of its width originated from half of the groove, but its other half from a deep groove between the free cotyledonary buds, leaving unoccupied the other half of the normal groove. It was considerably torn, and from its position was at first taken for an extra leaf such as that shown in text-fig. 1. That part of the inner ridge which surrounded the cotyledonary bud encircled on two sides by the leaf in this abnormal fashion was unusually well-developed and zoned; meristematic division had evidently been very active there. On the outer side of the leaf a small extra lobe (B 3) was also present and another lobe, not shown in the figure, occurs at B 4.

A transverse section through the hypocotyl (of the specimen represented in fig. 8) at the level of entry of the leaf-bundles shows a straight row of bundles entering from one leaf, and an L-shaped series from the other, the hook of the L passing between the bases of the two main buds (Pl. 35. fig. 23).

The fact that half of one side of the "leaf-groove" is here unoccupied by a leaf appears to me to be a fact of some interest. It makes more evident the independent growth of the two ridges (the two lips of the groove), a fact more surprising here than in the normal plant, where they are separated from one another by the base of the leaf.

The presence of *extra lobes to the crown* was found in one other case besides that recorded above. In this example one lobe was divided into three (fig. 5), but

* It is also interesting to notice that this seedling, like the one with the extra leaf, was found by Professor Pearson near Mossamedes, a comparatively damp district, in which *Welwitschia* manifests unusually active growth.

the three portions had a common base. The two main lobes were widely separated and were each surrounded by the well-developed inner ridge.

Cases in which one lobe or bud is more strongly developed than the other are fairly common.

In conclusion, it will be obvious from this description of the development in seedlings of *Welwitschia* that the epicotyledonary stem is extremely reduced in this plant, and that practically the whole tuberous mass, commonly known in the adult plant as a stem, is morphologically the swollen hypocotyl which bore in rapid succession the two cotyledons and the two plumular leaves. The stem apex gives rise only to these two leaves and is suppressed early in the life of the seedling. It is finally in most cases even buried by the growth of the cotyledonary buds.

The only portion of the plant which can be regarded as the epicotyledonary stem is that which undergoes intercalary growth above and below the leaf-bases. In the early stages the leaves originate at practically the same level as the cotyledons; it is only later that they become widely separated by further growth, which begins between the margins of the cotyledons as a small projection and finally develops into the outer ridge. But it must be noted that this ridge does not elevate the leaf-bases in a manner which can be compared with the separation of two nodes by the ordinary elongation of an internode. The ridge is a quite independent structure and has from the beginning a special vascular supply. It appears very doubtful whether either it, or the inner ridge, which originates later by intercalary growth on the inner side of the groove, can really be regarded as normal epicotyledonary stem. These ridges are rather of the nature of specialised placental outgrowths on either side of the leaf-base.

In any case the extent of this growth-region is extremely small in comparison with the large swollen hypocotyl, which may also grow considerably in length (E marks the level of the feeder in fig. 4 *b*); the many peculiarities of the vascular structure and transition are probably to a large extent attributable to this remarkable elongation of the hypocotyl.

The plant is really an "*adult seedling*"; and there are few forms with which it can strictly be compared. It presents some points in common with seedlings of *Araucaria Bidwillii*. At that stage in the growth of a seedling of *Araucaria Bidwillii* at which the cotyledons wither, the plant "is capable of resisting drought, and may be sent to Europe without losing the power of germination. It has been suggested that the first stage of germination may correspond with a short rainy season, while the resting stage coincides with the period of drought"*. *Welwitschia*, living in a climate in which the period of drought is indefinitely prolonged, appears to have got very little further in its development than has such a seedling!

It will be seen later that in its anatomy, especially in the transition region, it has other points of still more striking resemblance to various species of *Araucaria* †.

* Seward and Ford, 1906, p. 331; see figs. 13, B (*Araucaria Bidwillii*) and C (*Araucaria imbricata*).

† Attention has been called by Prof. Pearson to another striking resemblance between *Welwitschia* and *Araucaria* (Pearson, 1909, p. 370).

Section II.—The Root System.

Occurrence of Branching.—In most of my plants the root system was not preserved intact, and the portion of the tap-root still attached to the plant, although in some cases of considerable length, was quite unbranched.

In the one case of branching found in the West African material a large stone was wedged in between the two portions, and it would appear probable that in this case the root had bifurcated owing to injury by the stone. In some of the West African seedlings there were remains of minute lateral roots, but they were very few and were sparsely distributed.

The seedlings from the Botanic Garden had been raised in stony soil in long drain-pipes. In one of them an early bifurcation of the root had taken place (Pl. 34. fig. 1, B); here also it had come into contact with a stone, and forked in consequence. In the other and older seedling there were several such bifurcations, and in each case anatomical examination showed that some injury had happened to the root at the point of bifurcation. Professor Pearson agrees with me in thinking it probable that bifurcation and the formation of strong lateral roots in this plant is always due to the influence of some such obstacle.

The two seedlings just referred to were strikingly different in one particular from the seedlings obtained growing in their natural habitat. The younger seedling in the lower parts of its root system, the older seedling throughout a large portion of its length up to within two inches of its feeder, bore numerous minute hair-like lateral rootlets. These rootlets (see H, Pl. 34. fig. 1) received a small vascular supply from one pole of the diarch main root. As the younger portion of the root system has been broken off, all the rootlets are unfortunately of considerable age and have lost their cortex by disintegration; they are protected by two or three layers of corky cells, internal to which is the minute stele, which contains two phloem groups and a very small diarch plate of xylem (Pl. 35. fig. 12).

These fine lateral rootlets have not been found in seedlings examined before. Bower records one case of the formation of a lateral root in consequence of injury *, and Chev. D. J. N. de Monteiro found cases of repeated branching in roots about eighteen or twenty inches long †; but these lateral roots appear to have belonged to an entirely different category from those just described. The occurrence of the fine rootlets, few in the desert plants, but numerous in these artificially grown seedlings, is a feature of some biological interest: it is probably dependent on the conditions under which the plant is grown. In the habitat normal to the plant the surrounding surface soil is absolutely bereft of moisture, except during that brief period of rainfall during which the seeds first germinate ‡; the development of absorbent organs by the descending tap-root would therefore be worse than useless, its one aim necessarily being to reach the underground sources of water. In the case of seedlings reared in the moister atmosphere of

* Bower, I. p. 26.

† Gard. Chron. 1880, p. 690; Bower, II. p. 571.

‡ Pearson, 'Nature,' 1907.

the xerophyte house at the Botanic Garden, the soil conditions cannot but be somewhat different; hence the production of the fibre-like rootlets for the absorption of the small amount of moisture thus presented to the root. It is probable that in this plant the formation of lateral roots is conditioned by the amount of moisture present.

Anatomy of Forking Root.—The anatomy of the normal elongated root and hypocotyl of *Welwitschia* has been described by other authors *, and full accounts have been given of their external appearance and internal structure and of the development of the ground-tissue, lignified fibres, &c. I have little further to add to their descriptions.

The forked root system described in the young seedling (Pl. 34. fig. 1) is, however, of some interest and seems worth a short description, since it affords an excellent illustration of the powers of endurance of this remarkable plant.

Text-fig. 2 (p. 336) represents a series of transverse sections from above downwards through the region of the root injured by contact with the stone. In text-fig. 2, A, the transition from hypocotyl to root structure is not quite complete, and the two groups of xylem in the stele are each monarch; while attached to each are two separate groups of secondary xylem and phloem, from which the normal diarch plate of the root has not yet been formed. Just above the place of injury it is seen that the secondary xylem and phloem of both poles of the root are laid down in four groups (text-fig. 2, B); the first sign of disturbance is seen in one of the protoxylem groups (*b*), which becomes elongated and irregular in appearance. The small bundle (*c'*) seen in connection with *b* in A, has died out; but the small bundle *c* in connection with group *a* is still present, accompanied as before by two others.

Immediately after the appearance of this irregularity in the group of protoxylem *b*, the whole group is destroyed, and this half of the vascular tissues is represented only by a decayed mass (*b*, text-fig. 2, C).

The other and larger plate *a*, with its small secondary bundles, still persists. The fact that similar small bundles are not present in connection with the plate *b*, as they are in all normal seedlings, shows that the injury to the root on that side must have taken place at an early stage before the age at which the additional peripheral bundles could have been laid down.

The single remaining protoxylem group is now surrounded by four large and several smaller groups of secondary xylem and phloem. The peripheral smaller groups move outwards, evidently in another attempt to supply a branch. This attempt meets, however, with the same fate as the first, and another dead plate of vascular tissue thus results (*c*, text-fig. 2, D).

The four remaining bundles are now arranged symmetrically round the group of protoxylem, and the root makes a third attempt: it divides at right angles to the plane of the two previous divisions, and a small portion of the vascular tissue is separated off from the larger portion which remains in the original main root. The root thus formed is successful in its development, but a small part of the remaining tissue subtending the rootlet in the main root is destroyed (*d*, text-fig. 2, E & F).

* Hooker, Bower, Bertrand, *ll. cc.*

† See Bower, I. & II.; also text-fig. 3 of this paper, p. 342.

At a level very little below the area of disturbance the two roots formed at this third attempt are found to be nearly of the same size and to have quite normal diarch structure (text-fig. 2, G).

There is one point of some interest shown in this figure which may be referred to here: a small mass of lignified elements, generally much stretched and ruptured, is seen on the

Fig. 2.

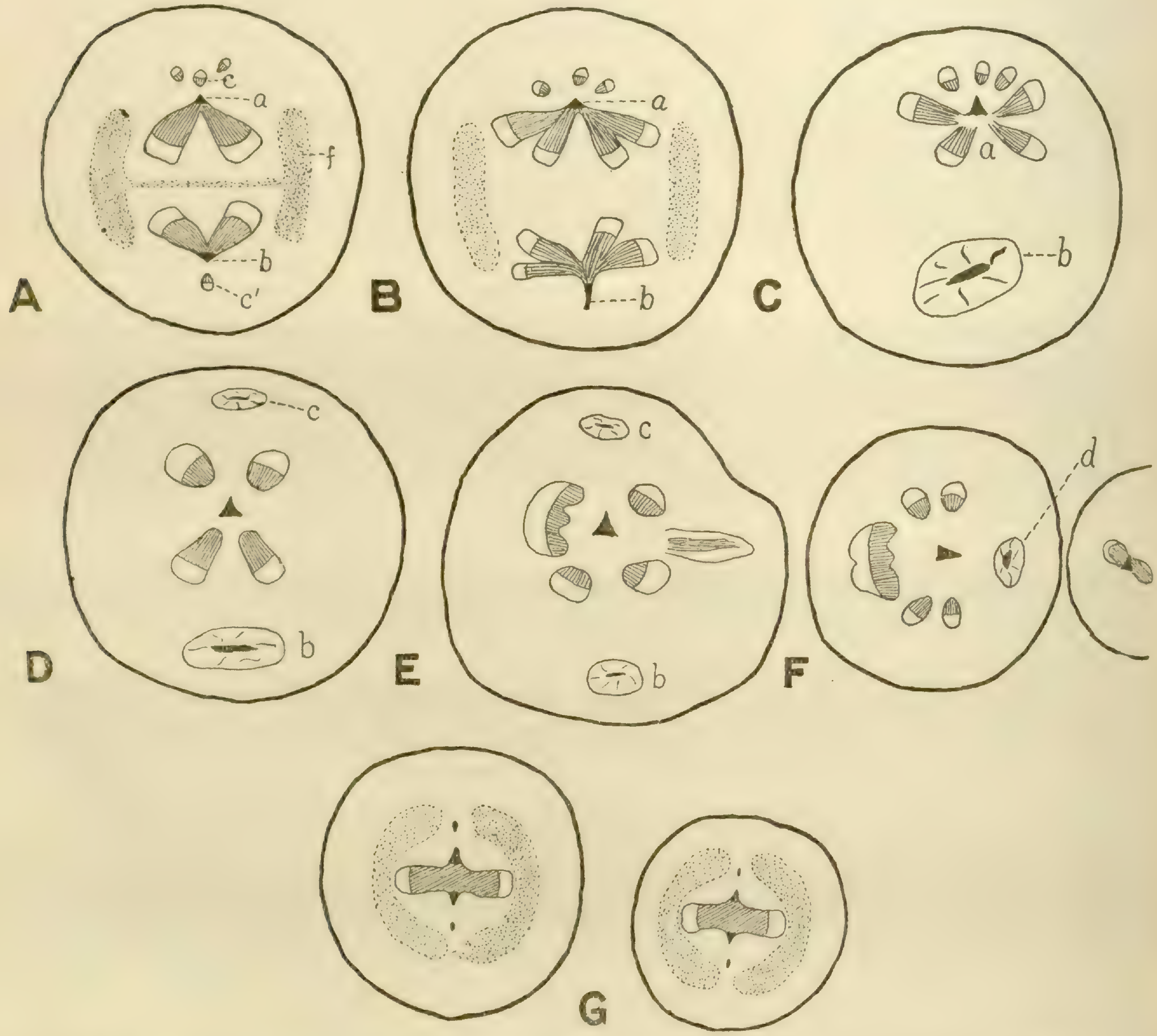


Fig. 2, A–G.—A series of transverse sections through the bifurcating root of the seedling shown in Pl. **34**. fig. 1 (secondary xylem = shaded, primary xylem = black, dotted area = fibres (*f*), phloem outlined).

outer side of each of the protoxylem groups, separated from it by several layers of parenchymatous cells (Pl. **35**. fig. 14). In text-fig. 2, G, these elements are very few in number, but in some cases they form a very considerable group and are often arranged in a triangle having its apex directed towards the apex of the triangle formed by the protoxylem of the main group. In such cases there is little doubt that the protoxylem

is to be regarded as mesarch; Bower, however, in his study of the early development of the seedling, did not come to this conclusion and merely points out the fact that the protoxylem is "long drawn out" *.

Section III.—The Structure of the Ridges and Young Inflorescences.

Some of the most interesting facts disclosed in this investigation are concerned with the development of the vascular elements in the ridges on either side of the leaf-bases, and their connection with the bundle-system of the hypocotyl.

General Structure of the Ridges.—In the young seedling (Pl. 34. fig. 1) the ridges, each as yet represented only by a small protuberant outgrowth (R), are made up of rapidly dividing parenchymatous cells, among which are scattered a few fibres with thickened and lignified walls: the epidermis is thin-walled and without stomata.

In the older seedling, fibres become very numerous in both ridges, and cork-formation extends over the base of the outer ridge on its outer surface. Numerous stomata are present in the epidermis of the upper free portion of both ridges; these stomata resemble those of the mature leaf, and the epidermis (also like that of the leaf) is composed of conical cells with a thick cuticle impregnated with calcium oxalate. This region with stomata extends over the outer surface of the outer ridge for some distance towards its base, but stomata are absent on its inner surface, where it forms one side of the leaf-groove, and the epidermis is there made up of small, closely packed, cubical cells unprovided with a cuticle. Stomata and cuticle are similarly absent from that part of the inner ridge which forms the other side of the leaf-groove.

Vascular System of the Ridges.—(*a*) In the seedling shown in Pl. 34. fig. 1 the vascular supply of the ridge primordium consists of a small group of bundles, which form a more or less concentric ring and end freely upwards (Pl. 35. figs. 15 *a* & *b*). Each bundle composing the ring is collateral, and all its elements appear to be secondary in origin. No transfusion-tissue is present at this stage. When the bundles are followed downwards in a series of transverse sections, it is seen that while one or two from each group join on to the pairs of primary bundles in the hypocotyl, the greater number end freely in the parenchyma separating the two pairs from one another †.

At this stage the inner ridge is as yet undeveloped, and there is no sign of a vascular supply either to it or to the cotyledonary buds.

(*b*) In the older seedlings, in which the outer ridge is elongated (*e. g.* in Pl. 34. figs. 1*a*, 2) and the inner ridge is just beginning to be apparent, the latter has still no vascular supply, but the simple ring of bundles which formerly terminated at the base of the outer ridge has now undergone some considerable change. The central mass of parenchyma is greatly enlarged, and the bundles are widely separated from one another and are more irregularly distributed; it can, however, still be seen that they constitute two series which together form an ellipse, the bundles of the two series being orientated inversely to one another. A good deal of transfusion-tissue accompanies all the bundles and is scattered

* Bower, I. p. 20, pl. 4. fig. 15, &c.

† See text-fig. 3, F, G, H, p. 342.

throughout the parenchyma (Pl. 35. fig. 19); and as the termination of the bundles is approached, this transfusion-tissue increases in amount. The bundles have kept pace with the upward growth of the ridge: in the upper and now free and elevated portion of the ridge the bundles of the outer series run inwards and terminate together with the inner series in a common irregular mass of scattered transfusion tracheids (Tr, Pl. 35. fig. 16). Anastomoses are frequent, so that the ridge is provided with a peripheral network of bundles running a little way beneath its surface. This is incomplete and open below, where the bundles run down into the hypocotyl and there join the main stele of the seedling. At this stage free endings are rare, most of the bundles having now become joined up with the four groups of vascular tissue found traversing the hypocotyl. The bundles of the ridge join on to the same two groups which supply the bundles of the subtending leaf.

(*c*) In the later stages (*e. g.*, Pl. 34. fig. 4) no important change takes place in the structure of the outer ridge. A large number of new bundles are intercalated by the rapid meristematic divisions of the parenchymatous tissue; these are chiefly added to the outer series, where they are often arranged in two or more rows, all with the xylem on the inner side of the bundle *.

In many cases the first-formed elements of the xylem in these additional bundles are not the innermost ones; but while a large portion of the later-formed xylem is centrifugally developed, a few tracheids are produced centripetally. Sometimes the centripetally developed xylem even exceeds the centrifugal in amount (Pl. 35. fig. 20). Nearly all the bundles are accompanied on the centripetal side by transfusion elements. There is an increased number of small transverse bundles at this stage, connecting the two series in the outer ridge.

The inner ridge is now traversed by a number of bundles (Pl. 35. fig. 18), most of which are connected with the inner series of bundles belonging to the outer ridge. In many cases they can be seen originating from this inner series and running in between the leaf-bundles at the base of the leaf-groove; they then bend upwards and form the irregular series of bundles which traverses the inner ridge and surrounds the cotyledonary buds: like the bundles in the outer ridge, they end in groups of transfusion-tissue.

Finally, in the oldest plant examined (Pl. 34. fig. 7) the following was the course of events as seen in a series of transverse sections:—In the uppermost portion of the outer ridge there is no sign of vascular bundles; about a centimetre from the surface are a number of groups of transfusion-tissue, which represent the endings of vascular bundles. These vascular bundles are mostly horizontal and are all very irregularly distributed, but followed downwards they are seen to become separated into two series orientated inversely to one another, between which run transversely a number of connecting bundles. Lower down these cross-connections decrease in number. At each end of the ridge a bundle, which represents one of the pair of bundles formerly passing out into a cotyledon, is still conspicuous and now functions as part of the vascular supply to the ridge. At the base of the outer ridge the inner series is much distorted, and its bundles twist round and anastomose with one another. Some of them join on to the outer series

* *Cf.* concentric rings in Cycads; also *cf.* trunk of *Cycadella*, Wieland, p. 66, fig. 35.

and pass down into the hypocotyl. Others pass out between the leaf-bundles under the base of the groove and supply the inner ridge and its inflorescences. On their way some of these bundles form connections by means of secondarily developed vascular elements with the secondary tracheids &c. of the leaf-bundles.

In these later stages it is not possible to follow accurately the course of the common bundle-supply of the two ridges in a downward direction. Free endings are rarely met with, but some of the bundles can be traced down below the level of the feeder before they fuse with the bundles of the hypocotyl.

Vascular Supply of the Young Inflorescence.—I was able to investigate the vascular supply of the young inflorescence * seen in Pl. 34. fig. 9. Its axis received a number of separate bundles (Pl. 34. fig. 11), which, in connection with the bundles of the inner ridge, had branched off from the vascular system of the outer ridge and passed under the groove between the leaf-bundles. Transverse sections of the axis of the young inflorescence showed its bundles to be distributed in two more or less irregular whorls *. In the outer whorl there were several cases of three, four, or more bundles arranged to form a concentric group †. No transfusion-tissue was yet present, and the pith was parenchymatous. It was quite clear that all the bundles were entirely composed of secondary elements produced by the tangential divisions of the meristematic parenchyma (Pl. 35. fig. 21).

It is interesting to notice that the bundles were better developed and the xylem more strongly lignified in the upper portion of the young inflorescence-axis. The bundles are therefore probably older in this region, a fact which would suggest that they develop first here and later become extended downwards. Similar facts were observed in the newly intercalated bundles in the young leaves.

It will be seen from this account that the vascular system in the young ridges and inflorescences is entirely secondary in origin, all the bundles being derived from the growth and further extension of the small concentric ring of secondary bundles which arises first in the outer ridge and later supplies vascular tissue to the inner ridge and the inflorescences.

Section IV.—The Cotyledonary Buds.

The young cotyledonary buds are composed entirely of parenchymatous tissue and have at first no vascular supply.

In the stage represented in Pl. 34. fig. 2, numerous fibres are distributed throughout the tissue of the now flattened cotyledonary buds, and corky tissue has been developed at their pointed ends. Each bud receives a number of small vascular bundles arranged to form an elongated series. In Pl. 35. fig. 17 it can be seen that the end bundles of the series are collateral and much curved, having their xylems regularly orientated towards the rest of the bundles. The remainder are, on the contrary, very irregularly distributed and may be collateral or concentric. At the apex of the bud the bundles tend to become

* A full description of the adult inflorescence axis is in course of publication by Sykes, in Phil. Trans. Roy. Soc. 1910.

† Worsdell, 1901, p. 768.

arranged into two groups: towards the base the series forms an almost continuous stele. It is not possible certainly to ascertain whether there be any primary elements in these bundles; but by far the greater number of their constituents are entirely of secondary origin.

The group of bundles running up into a cotyledonary bud originates from the two bundles of the cotyledon in the axil of which the bud is borne: it is interesting to find that the vascular supply of the cotyledonary bud bears the same relation to that of the cotyledon as does the vascular supply of one of the flowers of the inflorescence or of one of the inflorescence-branches to the bract in the axil of which it is borne *.

In the older cotyledonary buds—or lobes of the crown, as they are often called in the later stages—cork-formation has extended over the whole surface. The original vascular supply does not seem to have undergone much change †, except that the bundles forming the elongated series have become more or less separated from one another by the growth of the parenchyma, and may in some cases appear to be arranged in a ring. At the base of the bud the inner ridge has now grown up ‡, and its bundles form a very irregular ring round the original bundles of the bud (Pl. 35. fig. 18); they run in all directions, and in some cases they appear to establish connections with the bud-bundles.

Section V.—Transition Phenomena.

I have now to describe various facts connected with the transition phenomena in *Welwitschia*, chiefly relating to the behaviour of the special bundle-system supplying the ridges. For this purpose it is necessary to give an account of the transition process in the main bundles, which traverse the root and hypocotyl and run into the cotyledons and leaves; this process is in itself of considerable interest in this plant, but Bower's clear description makes it superfluous to give a second full account, and I propose merely to give the outlines, laying especial stress on peculiarities which are here for the first time demonstrated, or which are important in the light of recent research.

Outlines of Transition.—The main facts in the youngest seedling are as follows:—Two bundles enter from each cotyledon, and almost immediately rotate to form the four exarch collateral bundles of the hypocotyl. After a considerable interval, the protoxylems of each pair fuse to form one of the poles of the root, the two phloems of the two groups thus produced remaining separate. Finally, one of the phloem groups from one pole joins one of the phloem groups from the adjoining bundle of the other pole, and there is thus produced a normal diarch root in which two phloem groups alternate with two xylem groups. There is no primary xylem in the hypocotyl, save that which passes out into the cotyledonary traces; similar facts have been described in *Araucaria* §.

Text-figure 3 (pp. 342–343) represents a series of transverse sections taken at intervals

* Strasburger, 1872, pp. 144, 145.

† Bower, II. pl. 32. fig. 9, p. 583.

‡ Bower, II. pp. 581, 582. Professor Bower's material did not make it possible to distinguish between the original vascular system of the bud itself and those later-formed bundles supplying the tissue of the rapidly enlarging inner ridge, by the growth of which the lobes of the crown are upraised.

§ Seward & Ford, 1906, pp. 333–336.

from an older seedling (Pl. 34. fig. 1) intermediate in age between that figured by Bower in his first paper * and the youngest of those described by him in his second paper †. Text-fig. 3, A, shows the diarch root; in B the two poles of the root have separated, and in C two separate collateral groups of vascular tissue are present at each pole; the two groups are connected with one another by meristematic tissue (text-fig. 3, C, *m*). The levels at which these sections are taken can be judged by reference to the older seedling drawn in Pl. 34. fig. 4 *b*, where A indicates the upper level of the diarch-root structure and the stage at which the separation of the two poles of the root begins, and C is the stage corresponding with text-fig. 3, C. The four groups of vascular tissue present at this stage are continued upwards into the hypocotyl; they remain collateral past the level of the feeder (Pl. 34. fig. 4 *b*, E, and text-fig. 3, E), up to the level F in Pl. 34. fig. 4 *b*, when they become concentric. The formation of four concentric groups, characteristic of the upper portion of the hypocotyl of *Welwitschia* ‡, is gradually brought about by the addition of small secondary bundles round each of the four original main collateral bundles. The beginning of this process is seen at F, text-fig. 3, where meristematic division has spread outwards from each group and produced a large inner bundle (*l*) and a number of small peripheral bundles. In G and H, text-fig. 3, the gradual establishment of the four concentric groups is seen. It is these four groups (reminiscent as they are of the concentric steles of the Medulloseæ §) which give to the vascular structure of the so-called "stem" of *Welwitschia* its very striking appearance ‖.

One of these concentric groups is drawn in detail in Pl. 35. fig. 22. A number of isolated tracheids are scattered throughout the parenchyma in the centre of the group. A single and fairly regular row of cells defines the limits of each of these groups, but it was not possible either here or at any other level to make out any of the characters which distinguish a definite endodermis, so that it does not appear correct to designate them as "steles."

In the short space intervening between levels G, I, text-fig. 3 (F and K in Pl. 34. fig. 4, *b*) ¶, the four separate groups are not so clearly defined. At I, text-fig. 3, the four main bundles have rotated on their own axes, and are now endarch; in K, L, M is seen their further rotation and the division of each bundle into two, so that four bundles run up into each cotyledon. The other bundles which made up the concentric groups supply the plumular leaves, K, L, text-fig. 3. Each leaf thus receives at this stage a number of bundles, some of which have been connected with one cotyledon trace, some with the other. One leaf-bundle from each concentric group is at these stages, text-fig. 3, E–I, remarkable for its greater size, and it appears probable that these four bundles represent the original leaf-supply, two to each leaf, before the intercalation of the secondary bundles began. In older seedlings the ever-increasing numbers of leaf-bundles often become distributed in rings more or less concentrically arranged

* Bower, I. pl. 4. fig. 15. † Bower, II. pl. 32. fig. 6.

‡ *Cf.* the folding of the cambium in the bundles of the peduncles; Sykes, 1910.

§ Weber & Sterzel; *cf.* Sykes, 1910, Phil. Trans. Roy. Soc. ined.

‖ *Cf.* the four groups of vascular tissue in *Convolvulus Scammonia*; Solereder, p. 572, fig. 131.

¶ In an older seedling the four hypocotyledonary groups were traced up to ¼ in. from the apex.

Fig. 3.

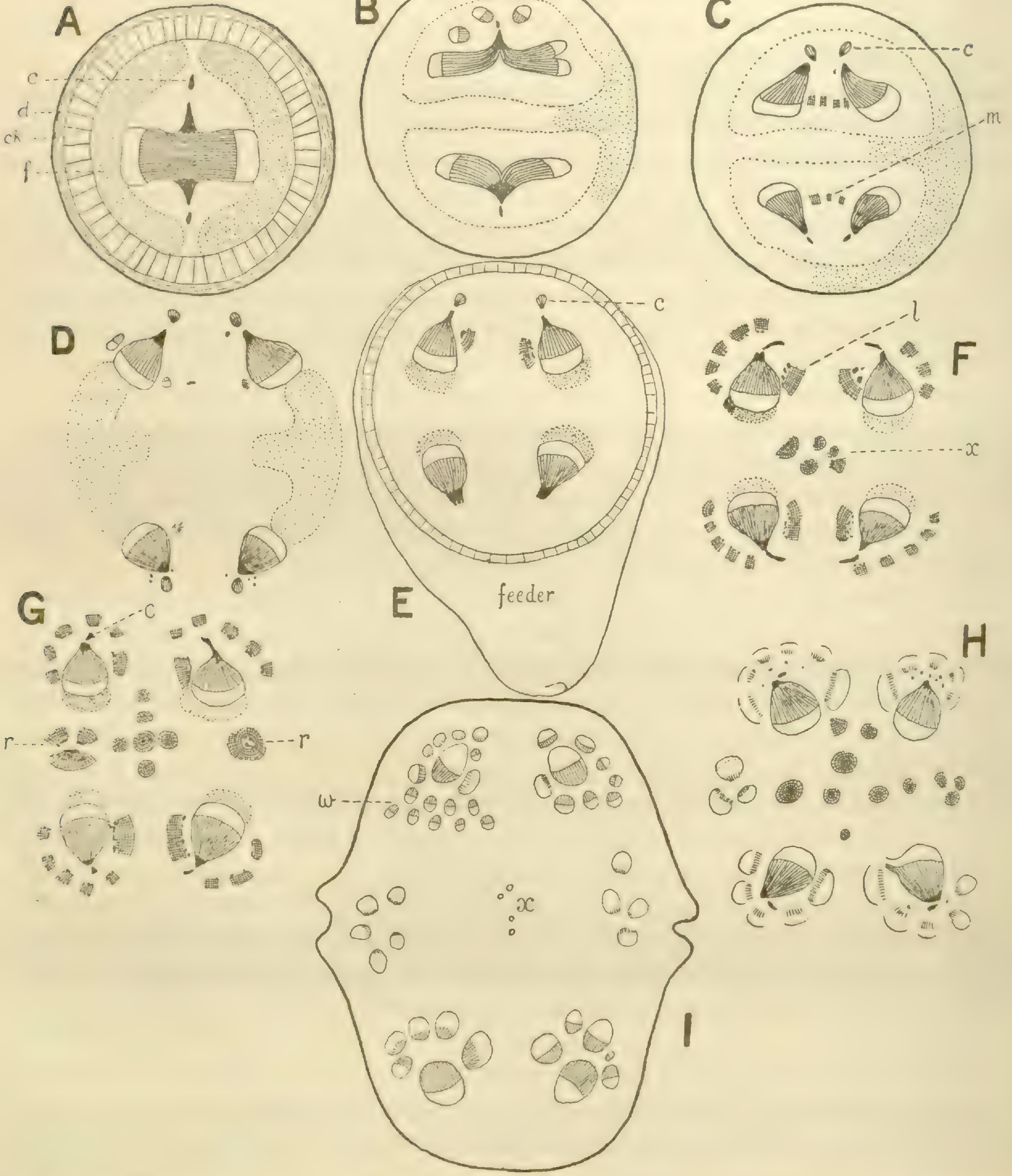
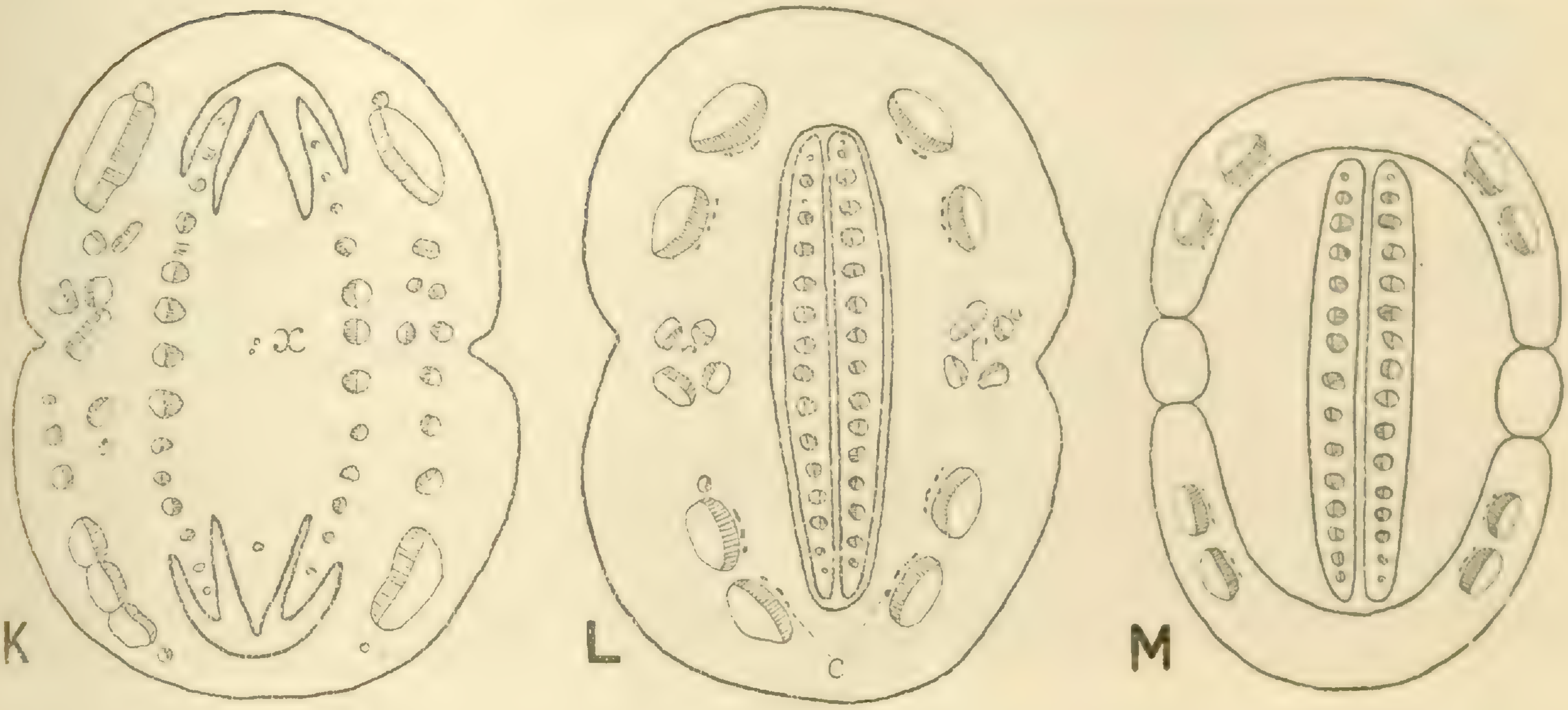


Fig. 3, A–M (described in text). d=dead cortex; ck=cork; f=fibres; c=outer isolated portion of xylem; m=meristematic divisions; x=bundles from ridges and cotyledonary buds &c., ending freely in pith; r=concentric series of bundles supplying ridges; l=main leaf-bundle. (Phloem=blank; xylem=shaded with fine lines; when a bundle consists merely of meristematic divisions it is represented by a cross-hatched area; fibres=dotted.) (K, L, M are inserted on the next page.)



in the hypocotyl *. Some suggestions of this arrangement are already visible at W, text-fig. 3, I.

The Vascular Supply of the Ridges.—In older seedlings this growing complexity makes it difficult to distinguish the four original cotyledonary bundles. This difficulty is increased and the distribution of the bundles made more irregular by the entrance of a large number of bundles from the ridges. It remains to draw attention to the presence of a few of these even in the young seedling just described.

At X, text-fig. 3, F, several bundles are seen ending freely in the pith. When these are traced upwards they tend to form two groups on the periphery of the hypocotyledonary vascular cylinder. These groups become (*r*, text-fig. 3, G) distinctly concentric, and their concentric arrangement is later still more obvious as they are traced upwards to their termination at the base of the developing outer ridge † (L, text-fig. 3).

Some of the bundles seen in the pith in F, G, H, text-fig. 3, end freely upwards; at their termination they are represented only by a few meristematic divisions (*x*, text-fig. 3, I, K). They probably represent the rudimentary vascular supply of the stem apex and cotyledonary buds ‡; in older seedlings no bundles were seen at the apex of the plant, but they were all prolonged into the cotyledonary buds. In a seedling in which the cotyledonary buds were very unequally developed (Pl. **34.** fig. 6) the bundle-supply first appeared much lower down on one side than on the other.

In the older seedlings the elliptical series of numerous bundles § then supplying the ridge (text-fig. 4) becomes secondarily connected with the bundles in the hypocotyl; half of the bundles from the ridge joining one pole of the hypocotyledonary system, and half joining the other pole. Bower's material did not make it possible for him to trace the development and origin of the ridge-bundles, and he does not appear to have clearly

* *Cf.* concentric rings in the Cycadaceæ, Worsdell, 1896 &c., and in *Cycadella*, Wieland, p. 66, fig. 35.

† A similar concentric series of bundles was followed downwards and found to end freely in the hypocotyl of the rather older seedling shown in Pl. **34.** fig. 6.

‡ Bower, II. p. 581.

§ *Ante*, p. 338.

distinguished the ridge-bundles from the later intercalated bundles of the leaf: he included both together in the "peripheral series" *.

Fig. 4.

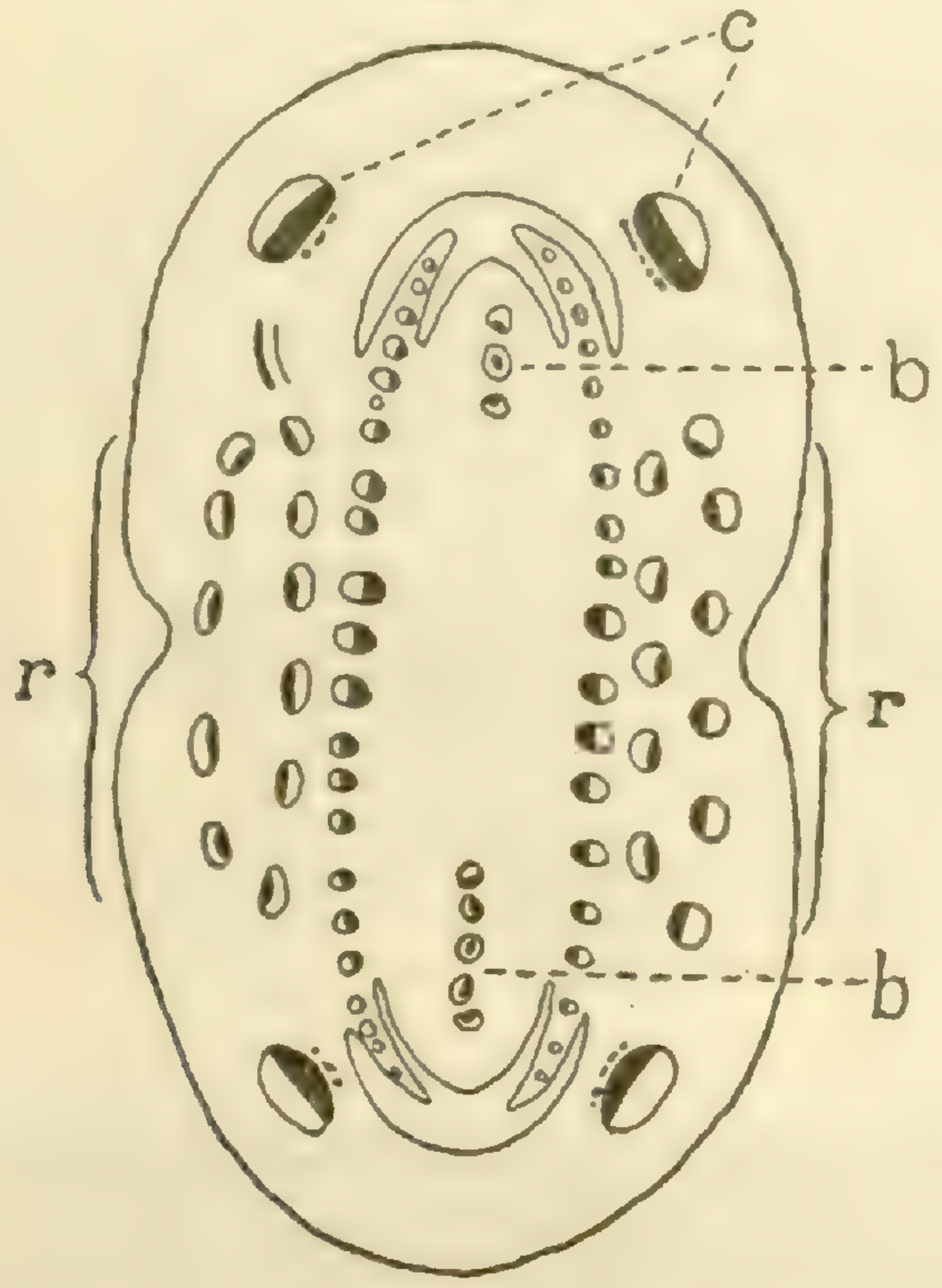


Fig. 4 represents a transverse section through the base of the leaf-groove in the seedling shown in Pl. 34. fig. 2. *r, r* represent the two elliptical series of bundles supplying the outer ridge; *b, b* = the row of bundles at the base of the cotyledonary buds; *c* = pair of bundles originally supplying a cotyledon. The bundles of each bud have a double origin from the two bundles supplying the cotyledon, in the axil of which the bud is borne.

It is of some interest that the bundles supplying the ridge originate in a manner so similar to those supplying the leaf which the ridge subtends. Both leaf and ridge receive a series of bundles which have a double attachment, being joined to one of the two bundles supplying each of the two cotyledons. There thus appears to be somewhat the same relation between the leaf and ridge-bundles as between the cotyledon and bud-bundles †.

Section VI.—Comparison of the Transition Phenomena in *Welwitschia* with those in other Gymnosperms.

The peculiarities in the behaviour of the vascular system in *Welwitschia* depend largely on the extraordinary slowness of the transition from the four endarch collateral bundles entering the upper part of the hypocotyl to the characteristic radial structure of the normal diarch root, and it is probable that they are chiefly due to the unusual length of the swollen underground hypocotyl in this plant.

In this connection it is interesting to refer to the seedling (Pl. 34. fig. 6) already described, in which the remains of the feeder were present immediately beneath the swollen part of the hypocotyl, and there was thus no elongated unswollen part of the hypocotyl developed. Here the transition was much more rapid than in the normal

* Bower, II. pp. 581, 582.

† *Ante*, p. 340.

eedling, but still retained its distinctive features. In the figures * A indicates the upper level of the normal diarch root, at B x the two poles of the root have diverged, C is the level of the formation of four separate groups, and E is the level of the feeder. Above the feeder the four groups are rapidly separated by the increase in amount of parenchymatous tissue, at H they begin to assume their concentric character.

It has been seen that the main features of the transition-region are the rotation of each cotyledonary bundle as a whole, and the fact that, while the exarch structure characteristic of roots is thus at once established, the collateral structure characteristic of stem-bundles is still maintained throughout the hypocotyl and the upper part of the root.

The transition phenomena in *Araucaria* † present the strongest resemblance to those in *Welwitschia*. Here also two bundles enter from each cotyledon and, finally, form one pole of the diarch root. The four cotyledonary bundles rotate as a whole, but it is only for a very short time that the four exarch bundles thus formed retain their collateral structure. The four xylem groups rapidly fuse in pairs, and the four phloem groups, becoming detached from the xylem, also fuse in pairs, thus establishing a normal diarch root-structure.

In *Podocarpus* ‡ the process is similar in essentials, but is still more rapid. Here again two bundles enter from each of the two cotyledons, and begin to rotate as a whole. Almost immediately, however, the xylem groups fuse in pairs and the phloem groups separate from them, and also fusing form two bands alternating with the xylem groups.

In *Sequoia* § the general plan of the transition is somewhat different, but in this case also the cotyledonary bundles rotate as a whole, retaining for a short time their collateral structure.

A few other isolated cases occur in which the bundles rotate as a whole, so that they are for a short part of their course exarch and collateral ‖, but in most Gymnosperms the transition is more rapid ¶; the xylem usually rotates alone, while the phloem group associated with it is separated from it before the bundle becomes exarch.

These few examples appear to suggest that the character of the transition phenomena is partly governed by the length of the hypocotyl, a factor probably to a large extent dependent on the habit of the plant; the long stage in *Welwitschia* in which the four collateral bundles have their xylems turned outwards is probably a special modification, and it does not appear that in this series a resemblance in such characters can be taken to denote phylogenetic relationship.

In the general features of their transition the Cycads do not resemble *Welwitschia*, but there are some remarkable points of comparison which appear to be of considerable interest. It will be remembered that the four collateral cotyledonary bundles in *Welwitschia* each form in the hypocotyl one constituent of a concentric group; such concentric groups are unique in character, but some parallel is afforded by the three

* Compare the relative levels in Pl. 34. fig. 4 *b*, described on p. 341.

† Hill, T. G., and De Fraine, II. 1909, p. 213.

‡ Hill, T. G., and De Fraine, I. 1908.

§ *Ibid.* I. 1908, pl. 35. fig. 13.

‖ E. g. *Pinus contorta*; *Ibid.* I. 1908, p. 205.

¶ *Ibid.* I., II., III., 1908, 1909.

concentric steles found in the hypocotyls of *Encephalartos Barteri* * and of *Cycas siamensis* †.

An abnormal seedling of *Araucaria Bidwillii* ‡, in which Shaw found four concentric steles, should also be mentioned in this connection.

The smaller concentric bundles scattered in the parenchyma of the hypocotyl of *Welwitschia* may be compared with the anomalous concentric cortical strands which are a characteristic feature of the roots of some Cycads §.

Section VII.—Centripetal Xylem in the Seedling.

Cotyledon and Ridge Bundles.—At the base of the cotyledons there are differentiated on the centripetal side of the cotyledonary bundles a small number of rather short broad tracheids with reticulately pitted walls (*cf.* L, M, text-fig. 3), which are often transversely connected with the bundles supplying the outer ridges. This centripetal wood dies out almost at once, before the bundles branch to form the parallel series which traverses the cotyledon: there is then no trace of centripetal elements.

In the 13 months old seedling no transfusion tissue was yet developed, and only a small amount of this tissue is present in connection with the bundles traversing the withering cotyledons of seedlings two to three years old. The transfusion tissue here first arises and is always best developed on the phloem side of the bundle, and it is not possible to trace any continuity between it and the centripetal xylem ‖.

A varying number of transfusion tracheids accompany the ridge-bundles during the upper part of their course; these occur mainly on the centripetal side of the xylem. The centripetally-developed tracheids both here and in the cotyledonary bundles are somewhat intermediate in character between the centrifugal xylem and the short wide transfusion-tissue elements scattered throughout the parenchyma of the ridges ¶. There were no unmistakable indications of centripetal xylem in the young bundles of the leaf.

Hypocotyl.—It is not easy to follow the exact behaviour of the centripetal xylem when the cotyledonary bundles rotate and become exarch in the upper part of the hypocotyl. Scattered tracheids are present throughout the parenchyma in the centre of each of the four concentric groups of vascular tissue which are there formed, and a small group of primary xylem is also present (Pl. 35. fig. 22) on the outer edge of the protoxylem **. The primary xylem is indeed often separated into two distinct portions, both of which are more or less triangular in cross-section, the apices of the triangles being directed towards one another.

In the lower unswollen portion of the hypocotyl, after the concentric character of the

* Worsdell, V. pp. 136–137.

† Matte, p. 189, fig. 248.

‡ Shaw, F. J. F.; see also Seward & Ford, p. 334, fig. 16, and p. 344, fig. 19.

§ *Cf.* Hill, T. G., and De Fraine, III. p. 442, for concentric strand in young root of *Macrozamia*.

‖ *Cf.* Scheit, who considers that the origin of the transfusion-tissue is always in the xylem (*ex* Worsdell, II. p. 303).

¶ *Cf.* Worsdell, V. p. 768.

** Bower remarks that the protoxylem in the hypocotyl is much elongated in a lateral direction, I. pl. 4. fig. 15, &c.

four groups has been lost, the differentiation of the primary xylem into two groups is still present. In some cases a little secondary xylem and even phloem are developed in connection with the smaller and outer portion (*cf.* C, text-fig. 3, E).

Root.—Still lower down the additional phloem group thus formed ends freely (*c*, text-fig. 3, C, p. 342), but the small mass of xylem extends much further downwards and appears and reappears throughout the root *, sometimes dwindling to a single tracheid †.

Text-figure 5, A–F, shows the changes which take place in this additional mass of xylem (*c*) in a portion of the root-system of the seedling shown in Pl. 34. fig. 2.

Fig. 5.

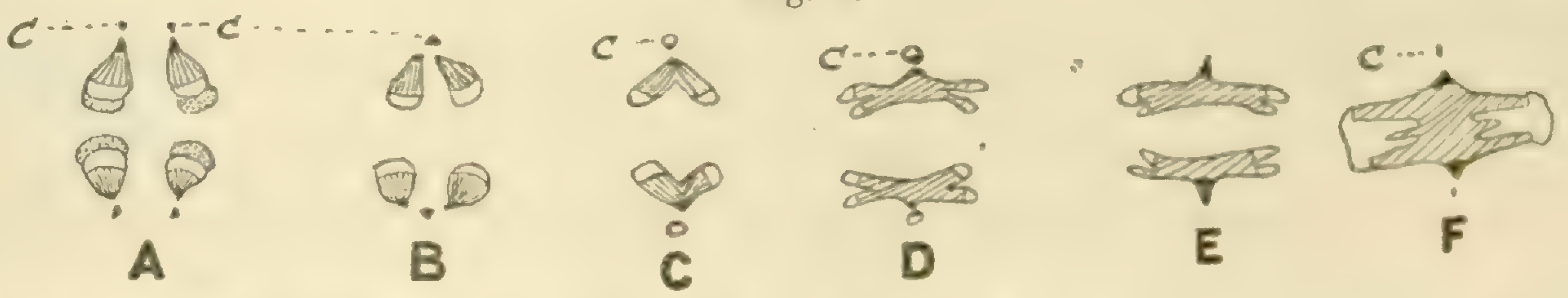


Fig. 5, A–F.—Phloem white; secondary xylem diagonally shaded; primary xylem black; fibres dotted.

It is to be noticed that at the fusion of the four hypocotyledonary bundles in pairs (B–C, text-fig. 5), the small outer masses of primary xylem fuse first, and the larger portions with the secondary xylem and phloem fuse later. At D the inner and outer groups of the primary xylem are seen to come into contact, and at E to fuse, but lower down at F a small group of four or five primary xylem elements is again separated off from the main bundle. At C and D a little phloem has been laid down in connection with the small outer group of primary xylem.

Section VIII.—Anatomy of the Adult Hypocotyledonary Stem.

General.—Concerning the anatomy of the adult hypocotyl, I have little to add to the account given by previous authors ‡.

The four concentric groups are still visible in very old plants. Newly intercalated bundles entering from the leaves are arranged more or less definitely with relation to these four centres, often forming a series of concentric rings. It is not, however, easy to define the outer limits of the leaf-series, as it is at a late stage indistinguishable from the series of numerous bundles supplying the ridges and inflorescences. The two series together compose Bower's "peripheral series."

Histology of the Xylem.—In the root and lower regions of the hypocotyl the tracheids of the protoxylem are reticulate (Pl. 35. fig. 14), while those of the secondary xylem have a single or double row of bordered pits (Pl. 35. figs. 13 & 14). The bordered pits are not contiguous.

In the upper portion of the hypocotyl, and in the ridges and leaves, many of the tracheids have both reticulate thickening and oblique or horizontal bordered pits § (Pl. 35. fig. 24, C).

* Cf. *Gingko*, Hill & De Fraine, III. 1909. † *Ante*, p. 337.

‡ Hooker, 1863; Bertrand, 1874; De Bary, 1884; Bower, II.

§ Compare Cupressineæ and some Leguminosæ.

Throughout the plant, except in the minute hair-like lateral rootlets *, there are also found wider elements, with three rows of bordered pits on their longitudinal walls, and having their transverse walls absorbed (Pl. 35. fig. 24 *a*, & Pl. 34. fig. 24 *b*) †, except for a small peripheral ridge ‡.

Comparative.—Since all the main essentials of seedling structure are preserved in the adult *Welwitschia*, it is obvious that the most important comparisons with other plants are those already made with various seedlings. I know of no recent plants whose stem anatomy can profitably be compared with the anatomy of the hypocotyl in *Welwitschia*; its whole adult structure is, however, strikingly reminiscent of that of the stems of some of the Medulloseæ.

The four concentric groups of secondary vascular tissue, each with tracheids scattered throughout its pith, are very like the large central steles of *Medullosa stellata* and the smaller but more irregularly arranged steles of *M. Solmsii*, while the peripheral series of secondary bundles, arranged as they often are in several concentric rings, may be compared with the outer rings of secondary elements in *M. stellata*, var. *gigantea*, &c.§

Resemblances in other respects between *Welwitschia* and the Medulloseæ have been indicated by the author elsewhere ‖.

Section IX.—General Conclusions.

1. The mature plant may well be described as an "adult seedling"; the main axis is differentiated into root and hypocotyl, and bears, in addition to the two cotyledons with buds in their axils, only two plumular leaves at the base of a deep groove. On either side of this groove there is a ridge made up of rapidly dividing parenchymatous tissue. A study of the development of these ridges shows that the outer ridge arises as a small projection between the margins of the cotyledon bases; the accelerated growth producing the projection afterwards spreads laterally and gives rise to the long ridge. Similar accelerated meristematic growth, at the bases of the cotyledonary buds, produces the inner ridge on which the inflorescences are usually borne. Further development in this region causes the apex to be completely buried by the enlarged cotyledonary buds or lobes of the crown.

2. The small projection from which the *outer ridge* is developed receives at first a concentric ring of secondary bundles which end freely downwards in the hypocotyl. As the ridge grows, numerous additional bundles are intercalated, and secondary connections are established between the bundles of the hypocotyl and those of the ridges. The bundles of the inner ridge and inflorescences are connected with those of the outer ridge.

3. Owing probably to the great length of the hypocotyl, the *transition* from the structure at the apex of the plant to the root-structure is remarkably slow. The two bundles of the diarch root fork and give rise to two pairs of bundles; each of these original pairs supplies one of the cotyledons in the seedling; they are still prominent even in plants of

* *Ante*, pp. 334–5.

† *Cf.* Gwynne-Vaughan.

‡ De Bary, p. 335; Bertrand, 1874, p. 16 (*Ephedra* and *Gnetum*).

§ Worsdell, V. pp. 133, 134.

‖ Sykes, 1910, I. p. 625, and II. ined.; *cf.* Worsdell on the Peduncle, IV. pp. 768–770.

considerable age, where they terminate in the outer ridge. The four collateral cotyledonary bundles are joined in the upper portion of the hypocotyl by the bundles which enter from the buds, ridges, and later from the leaves. The rotation of all the bundles takes place almost as soon as they enter the hypocotyl, and there is therefore not at any time a characteristic stem-like structure. The associated bundles form at once four concentric groups, but many of the more newly intercalated bundles of the leaves, &c., may be separately prolonged downwards for a greater or lesser distance before they become connected with one of these groups.

The bundles entering from a bud are joined on to both the constituents of the double trace of the cotyledon subtending the bud; but each ridge receives bundles which are connected with one member of each pair of cotyledonary bundles, and the same is true of the leaf, one half of each leaf-trace being associated with a member of each of the double cotyledonary traces.

4. The *method of transition* in *Welwitschia* is found to be most closely comparable with that in *Araucaria*. *Welwitschia*, *Araucaria*, *Podocarpus*, and some other forms make up a series, in all of which two bundles enter from each cotyledon and form one pole of the diarch root; in each case the collateral cotyledonary bundles rotate as a whole, and after a time the xylems of a pair of bundles fuse together, while the phloems leave them and fuse with the phloems of the other pair. The members of the series differ in the distance over which this process extends, according to the length of the hypocotyl. In other Gymnosperms the transition is still more rapid and the cotyledonary bundles do not rotate as a whole. It is thought probable that in this series the resemblance in the form of the transition is thus dependent on habit and not on relationship.

5. One of the most remarkable characteristics of the anatomical structure of *Welwitschia* is the *small amount of primary vascular tissue* in this plant. The development of primary xylem and phloem is limited to the poles of the root and the four main hypocotyledonary bundles, which are derived from the two poles, and which supply the cotyledons. The bundles supplying the two ridges and the inflorescences are clearly entirely derived from meristematic divisions of the parenchyma, and it is only later that they are connected by cambial divisions with the primary bundles.

The small size of the bundles in the cotyledonary buds makes it impossible to be certain whether or no there is any primary xylem present, but it appears most probable that there is none. The possibility remains that there is primary tissue in the two original pairs of bundles which first supplied the leaves. I have no material young enough in which to investigate this, as the first-formed xylem elements in quite young leaf-bundles get disrupted and separated from one another in consequence of the tension exerted by the rapid growth going on at the base of the leaf. But in the newly intercalated leaf-bundles all the xylem elements are arranged in tangential rows, and are continued downwards into the hypocotyl by secondarily developed elements, which connect them with the cotyledonary bundles (*m*, text-fig. 3, C). In the younger seedlings this connection is established by means of a meristem only, no xylem elements having yet been lignified.

In the young plant the bundles are all better developed and the xylem more strongly lignified in the upper part of their course through the ridges, inflorescences, and leaves than in their downward extensions into the hypocotyl. It would appear that vascular bundles are differentiated in the earlier stages of these organs, and are later continued downwards and become associated with the four original cotyledonary bundles, thus giving rise to the four concentric groups so characteristic of the hypocotyl of *Welwitschia*.

Such a series of facts appears to me to indicate that in this plant no distinction between primarily and secondarily developed vascular tissue is possible for purposes of morphology *.

6. *Centripetal xylem* is developed in connection with the four bundles in the bases of the cotyledons, and after the bundles have rotated a small isolated group of primary tracheids accompanies the four exarch bundles down the hypocotyl, and is also associated with the bundles of the root during the greater part of their course. It is obvious that this separate peripheral mass of primary xylem occupies the same position relative to the protoxylem as did the centripetal xylem in the cotyledonary bundles before they rotated, although its position relatively to the centre of the hypocotyl is now exarch.

In many of the outer series of bundles in the outer ridge, although these are entirely secondary, the first-formed elements are not the innermost ones, and some xylem is formed in both centrifugal and centripetal directions. In longitudinal section transfusion tracheids can also be seen on the centripetal side of many of the ridge-bundles: these merge gradually into the transfusion-tissue which is profusely scattered among the parenchyma.

7. It is difficult to make any close *comparison with other plants*. The retention of the seedling characters in the adult plant makes comparison with other seedlings of most interest, but since the vascular structure of seedlings probably depends to a remarkable extent on their habitat and environment, such comparison is probably not the most profitable for indicating relationships. The most remarkable character in *Welwitschia* is its four concentric groups of vascular tissue, with primary xylem tracheids scattered in their pith. Concentric steles are found in the hypocotyls of the seedling of some Cycads, and have been described in an abnormal seedling of *Araucaria Bidwillii*.

Such concentric groups are, however, most comparable with the several central steles of the Medulloseæ, and the peripheral series of secondary vascular bundles also recalls the outer rings of secondary vascular tissue in these plants.

8. The *method of branching* of the root when injured by stones or other obstacles has been described, and its investigation has afforded fresh evidence of the remarkable vitality of this plant. A seedling grown under conditions damper than the natural was found to develop a number of minute lateral rootlets.

9. Certain interesting *abnormalities* have been recorded in which (1) extra leaves have been produced in cases where the apex has not been completely buried, (2) one of the two normal leaves has been abnormally developed, or (3) further lobing of the cotyledonary buds has taken place. These have not thrown much light on the morphology of the plant.

* Worsdell, V. p. 141.

This investigation of seedling and adult plants of *Welwitschia* has served still further to confirm the previous impression of the aberrant nature of its structure, correlated as it doubtless is with its peculiar habitat and mode of life.

Bibliography.

Bertrand, C. E.—Anatomie des Gnétacées et des Conifères. Paris, 1874; and Ann. Sc. Nat., Bot. sér. 5, tom. xx. (1874) p. 8.

Bower, F. O.—I. On the Germination and Histology of the Seedling of *Welwitschia mirabilis*. Q. J. M. S. vol. xxi. (1881) p. 15.

II. On the further Development of *Welwitschia mirabilis*. Q. J. M. S. vol. xxi. (1881) p. 571.

De Bary, A.—Comparative Anatomy of Phanerogams and Ferns. Engl. ed. by F. O. Bower and D. H. Scott. Oxford, 1884.

Gwynne-Vaughan, D. T.—On the real Nature of the so-called Tracheides in Ferns. Ann. Bot. xxii., 1908.

Henriques, J. A.—*Tumboa Bainesii*. Trabalhos da Academia de Sciencias de Portugal, 1er série, i. Lisboa, 1908; and Bot. Centralbl. 1909, No. 29.

Hill, T. G., and H. De Fraine.—On the Seedling Structure of Gymnosperms.
I. Ann. Bot. vol. xxii., 1908.
II. „ „ vol. xxiii., 1909.
III. „ „ vol. xxiii., 1909.

Hooker, J. D.—On *Welwitschia*, a new Genus of Gnetaceæ. Trans. Linn. Soc. Lond. vol. xxiv., 1863.

Matte, H.—Recherches sur l'appareil libéro-ligneux de Cycadacées. Thèse. Caen, 1904.

Monteiro, D. J. N. de. *Welwitschia* Germination. Gard. Chron. n. s. xiv. (1880) p. 690.

Monteiro, J. J. Angola and the River Congo, vol. ii. (1875) p. 228, pl. 15.

Naudin, C. Gard. Chron. n. s. xvi. (1881) p. 217.

Pearson, H. H. W.—I. Some Observations on *Welwitschia mirabilis*. Phil. Trans. B, vol. cxcviii., 1907.
II. The Living *Welwitschia*. Nature, vol. lxxv., 1907.
III. Further Observations on *Welwitschia*. Phil. Trans. B, vol. cc., 1909.

Seward, A. C., and S. O. Ford.—The Araucarieæ, Recent and Extinct. Phil. Trans. B, vol. ccxcvii., 1906.

Shaw, F. J. F.—The Seedling Structure of *Araucaria Bidwillii*. Ann. Bot. vol. xxiii., 1909.

Solereder, H.—Systematic Anatomy of Dicotyledons. Engl. ed. by L. Boodle and F. E. Fritsch. London, 1908.

Strasburger, E.—Die Coniferen und die Gnetaceen. Jena, 1872.

Sykes, M. G.—The Anatomy and Morphology of the Leaves and Inflorescences of *Welwitschia mirabilis*. I. Proc. Roy. Soc. vol. lxxxii. II. Phil. Trans. B, vol. cci., 1910. (Ined.)

Weber, O., and J. T. Sterzel.—Beiträge zur Kenntnis der Medulloseæ. Chemnitz, 1896.

Wieland, G. R.—American Fossil Cycads. Carnegie Inst., Washington, 1906.

Worsdell, W. C.—I. Anatomy of the Stem of *Macrozamia* compared with other Genera of Cycadaceæ. Ann. Bot. vol. x., 1896.
II. On Transfusion Tissue. Trans. Linn. Soc. ser. 2, Bot. vol. v., 1897.
III. The Vascular Structure of the Flowers of the Gnetaceæ. Ann. Bot. vol. xv., 1901.
IV. Contribution to the Comparative Anatomy of the Cycadaceæ. Trans. Linn. Soc. ser. 2, Bot. vol. vi., 1901.
V. The Structure and Origin of the Cycadaceæ. Ann. Bot. vol. xx., 1906.

EXPLANATION OF THE PLATES.

PLATE 34.

Figs. 1 & 1 *a* are drawn from seedlings grown in the Botanic Garden, Cambridge ; the other seedlings figured were obtained from Professor Pearson's material.

(Except when otherwise mentioned, the drawings are life-size.)

Fig. 1. Seedling about 13 months old. C=cotyledon ; P=leaf; R=small swelling projecting from the common bases of the cotyledons at their point of junction ; F=feeder still enclosed in seed-coat ; B=bifurcation of root ; H=minute lateral rootlets.

1 *a*. A young seedling of about 24 months. A small ridge (R) is here shown, and is evidently derived from one of the processes (R) seen in fig. 1. A triangular portion (T) beneath the ridge has been intercalated between the bases of the old cotyledons, which are, however, still marked by a small projecting edge (*c*), which is prolonged for a short distance in a downward direction. L=back-turned plumular leaf ; C^1, C^1=bases of old cotyledons.

2 *a* & *b*. Older seedling. Y=the swollen portion of the hypocotyl; X=slightly flattened top of hypocotyl, with the ragged remains of the base of the cotyledons (C) ; L=one of the plumular leaves (the other has been removed) ; B=buds in the axils of the cotyledons; G=groove at the base of which the leaves take their origin ; R=ridge formed partly from the bases of the old cotyledons and partly from the further growth of the swellings seen in fig. 1.

3. Seedling a good deal larger and probably somewhat older than that shown in fig. 2, but in some respects less advanced in development. K=upper cylindrical portion formed by the further swelling of the fusiform hypocotyl ; U=unswollen part of hypocotyl ; C=downward sloping scars, which represent part of the areas of attachment of the two old cotyledons, now separated from one another by the growth of the region between the cotyledons, which has resulted in the formation of a more or less triangular portion (T), the triangle having its apex directed downwards ; the ridges (R) are still separate and do not extend round the ends of the groove, but are limited to its two sides. Other letters as before.

4 *a*. An older seedling. Br=a small ridge, the inner lip of the leaf-groove, which has now grown up round the base of each of the buds (B).

4 *b*. The same seedling, seen in another position. Letters denote levels determined by sections :—A=the upper level of the diarch root-structure; between A and C a gradual separation of the two poles of the diarch root takes place which is complete at Bx ; C=the level at which the separation of the xylem and phloem groups at the two poles begins, resulting in the formation of four exarch collateral bundles ; E is the probable original level of attachment of the seed, as judged by the drawing out of two of the bundles opposite the point of attachment of the feeder ; at F the four groups become more or less concentric; H is the level of the base of the ends of the groove and the origin of the cotyledonary buds ; L, a little higher, is the level of attachment of the base of the plumular leaves at the sides of the groove. It is seen that the groove is deeper at the ends where the buds arise than at the sides, where it is raised up by the growth of the bases of the leaves.

4 *c*. The same seedling seen from above, after the removal of the tops of the buds. The inner ridge (Br) at the base of the buds is seen to be continuous round the two buds, but not to pass in between them. Other letters as before. (× 2.)

5. Top of a young plant, showing one of the cotyledonary buds divided into three lobes.

Fig. 6. Young seedling in which the hypocotyl is unusually short, the feeder being still present immediately beneath the swollen portion. The two leaves of the seedling were contiguous by their adjacent faces and the cotyledonary buds were very minute. Letters as in fig. 4 *b*. For description see text, pp. 343–4.

7. Young plant with widely diverging cotyledonary buds, each surrounded by a separate inner ridge. Between the two buds is seen the structure A, which is described in the text, p. 332.

8 *a*. Top of a young plant with unfused cotyledonary buds seen from above. One leaf has been removed, the other is torn and part of it only is present. This part (p^2) is in an abnormal position, between the two cotyledonary buds. In fig. 8 *b*, drawn from a side view of the plant, the whole of the base of this abnormal leaf is visible, and it is seen that, while half of it is situated in the leaf-groove (G_1), the other half passes round one of the cotyledonary buds and takes its origin from the groove separating the two buds. The other half of the "leaf-groove" (G_2) is unoccupied by any portion of the leaf. B_3, B_4 = extra lobes of the crown, originating from the base of the groove, *outside the leaf*. The ridge (Br) round the left lobe of the crown is unusually well developed and is zoned.

9 *a*. Top of a plant seen from above. All trace of the original separate development of the two lobes of the crown is lost, except for some indications of the line of fusion seen at F. Indentations at O, O^1 still afford evidence of the double origin of the two ridges. A young inflorescence is seen.

9 *b*. Same plant, seen from the side. A portion of the lower ridge has been removed, in order to show clearly the origin of the young inflorescence from the inner ridge.

10 *a*. Transverse section through structure *a* in fig. 7, taken about halfway between its base and apex. F = fibres; L = cells with lignified walls. × 116.

10 *b*. Ditto, higher up than 10 *a*, showing fully developed group of fibres. × 116.

11. Diagram of section through young inflorescence and inner ridge in fig. 9 *a*. Shows origin of inflorescence from base of pit, supplied by several vascular bundles. B = section through brown upper portion of the crown. × 2.

24 *b*. (See explanation to Plate **35**.)

Plate 35.

Fig. 12. Transverse section of minute hair-like lateral rootlet, from seedling grown in the Cambridge University Botanic Garden. B = decayed cortex, &c.; C = corky cells; P = phloem; X = xylem. × 170.

13. Part of longitudinal section through similar but older rootlet. F, F = thick-walled unlignified fibres; P = sieve-tube; X = xylem. × 170.

14. Part of longitudinal section of main root. Pxy = protoxylem; C = tracheid separated from the protoxylem by two layers of parenchyma. × 170.

15 *a*. Transverse section through concentric ring of bundles at the base of small protuberant outgrowth (the ridge primordium) shown at R in Pl. **34**. fig. 1. C = point of junction of the bases of the cotyledons. × 116.

15 *b*. Transverse section of the other similar outgrowth on the same plant. × 116.

16. Transverse section not far from the top of the outer ridge of the plant shown in Pl. **34**. fig. 2. Tr = transfusion-tissue at the common endings of the bundles of the two series; F = fibres; St = stomata; C = corky tissue. × 50.

17. Transverse section of young cotyledonary bud in Pl. **34**. fig. 2, showing elongated series of vascular bundles. C = cork; A, a', a'' end in a common concentric bundle; B and b' in a second ditto. × 170.

Fig. 18. Transverse section of lobe of the crown in fig. 4. O = original bud-bundles; R = irregular bundles supplying inner ridge. × 75.

19. A small part of a transverse section through the outer ridge of the plant in Pl. **34**. fig. 2. F = calcium oxalate fibre; Tr = transfusion tracheid. × 170.

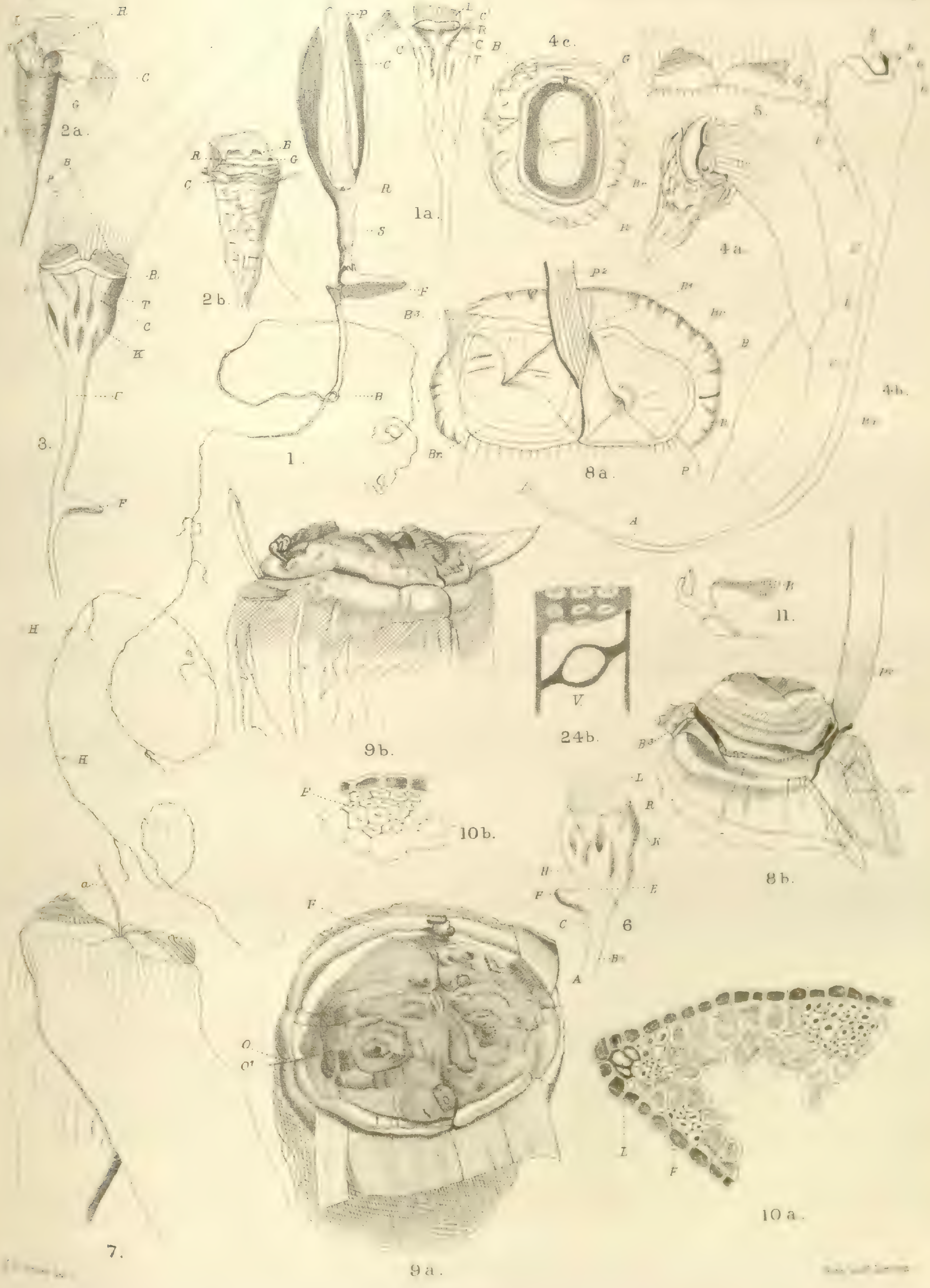
20. Bundle from outer series in the outer ridge of plant drawn in Pl. **34**. fig. 2. Cf = centrifugal side of bundle; Cp = centripetal side of bundle; Pxy = protoxylem; Ph = phloem; Tr = transfusion tracheid. × 116.

21. Transverse section of bundle from young inflorescence axis, showing all the elements to be arranged in radial rows. × 170.

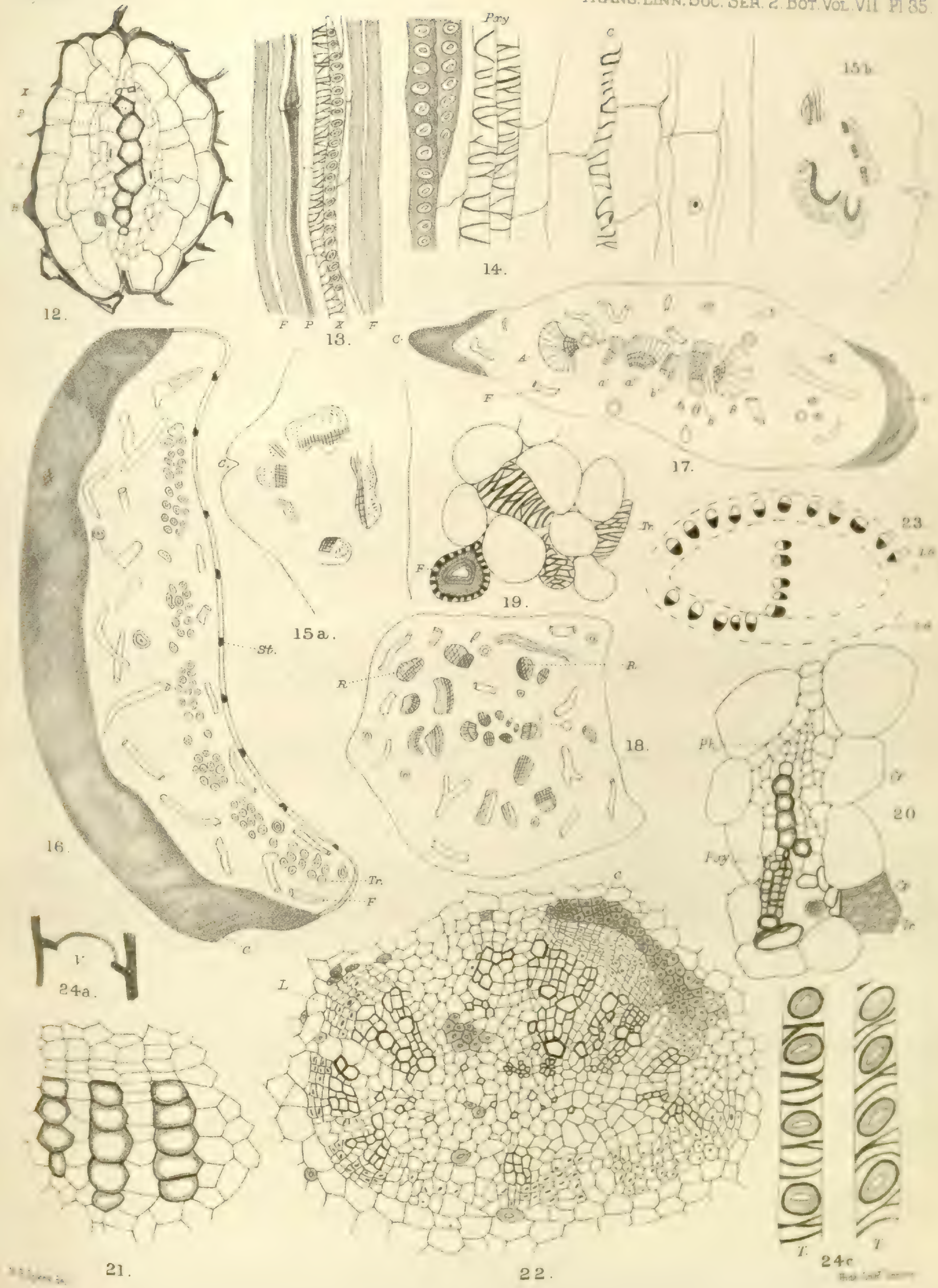
22. One of four concentric groups of vascular tissue in the hypocotyl of the young seedling shown in Pl. **34**. fig. 1. C = bundle supplying cotyledon; L = bundles supplying leaf; the other bundles probably represent the newly intercalated secondary leaf-bundles and the bud-bundles. Note the scattered tracheids in the centre of the group and the protoxylem group at the apex of bundle C. (See text, p. 341.) × 170.

23. Diagram of C-shaped leaf-trace supplying the abnormal leaf in the plant drawn in Pl. **34**. fig. 8. LG = boundary of leaf-groove.

24 *a*, *c*, & 24 *b* (see Pl. **34**). Various elements of the xylem showing pitting and thickening. V = vessel; T = tracheid.



ANATOMY OF WELWITSCHIA MIRABILIS.



ANATOMY OF WELWITSCHIA MIRABILIS.

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8s. to the public, and 6s. to Fellows; to **Vols. 26–30, 4s. to the public, and 3s. to Fellows.**

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

Second Series.—Botany.

Volume.		When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
I.	Parts I.–IX. (complete).	1875–80.	8	1	0	6	1	0
II.	Part I.	1881.	0	12	0	0	9	0
	Part II.	1882.	0	5	0	0	3	9
	Part III.	1883.	0	10	0	0	7	6
	Part IV.	1883.	0	3	0	0	2	3
	Part V.	1883.	0	3	0	0	2	3
	Part VI.	1884.	0	13	6	0	10	0
	Part VII.	1884.	0	9	6	0	7	0
	Part VIII.	1884.	0	10	0	0	7	6
	Part IX.	1886.	0	7	0	0	5	0
	Part X.	1887.	0	3	4	0	2	6
	Part XI.	1886.	0	6	0	0	4	6
	Part XII.	1886.	0	8	0	0	6	0
	Part XIII.	1887.	1	7	0	1	0	0
	Part XIV.	1887.	0	7	0	0	5	0
	Part XV.	1887.	0	10	0	0	7	6
	Part XVI.	1888.	0	2	6	0	2	0
III.	Part I.	1888.	3	12	0	2	14	0
	Part II.	1891.	0	5	0	0	3	9
	Part III.	1891.	0	7	0	0	5	0
	Part IV.	1891.	0	6	0	0	4	6
	Part V.	1891.	0	6	0	0	4	6
	Part VI.	1891.	0	3	6	0	2	8
	Part VII.	1892.	0	6	0	0	4	6
	Part VIII.	1893.	0	6	0	0	4	6
	Part IX.	1893.	1	8	0	1	1	0
	Part X.	1894.	0	10	0	0	7	6
	Part XI.	1894.	0	3	4	0	2	6
IV.	Part I.	1894.	1	0	0	0	15	0
	Part II.	1894.	2	0	0	1	10	0
	Part III.	1895.	2	10	0	1	17	0
	Part IV.	1895.	0	3	4	0	2	6
V.	Part I.	1895.	0	9	0	0	6	9
	Part II.	1895.	0	12	0	0	9	0
	Part III.	1896.	0	6	0	0	4	6
	Part IV.	1896.	1	0	0	0	15	0

Second Series.—Botany (*continued*).

Volume.		When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
V.	Part V.	1896.	0	14	0	0	10	6
	Part VI.	1896.	0	4	0	0	3	0
	Part VII.	1897.	0	4	0	0	3	0
	Part VIII.	1897.	0	6	0	0	4	6
	Part IX.	1899.	0	12	0	0	9	0
	Part X.	1899.	0	6	0	0	4	6
	Part XI.	1899.	0	7	0	0	5	0
	Part XII.	1899.	0	12	0	0	9	0
	Part XIII.	1900.	0	1	6	0	1	2
	Part XIV.	1900.	0	3	0	0	2	3
	Part XV.	1901.	0	6	0	0	4	6
VI.	Part I.	1901.	1	10	0	1	2	6
	Part II.	1901.	0	6	0	0	4	6
	Part III.	1902.	0	18	0	0	13	6
	Part IV.	1903.	0	8	0	0	6	0
	Part V.	1903.	0	8	0	0	6	0
	Part VI.	1903.	0	12	0	0	9	0
	Part VII.	1904.	0	12	0	0	9	0
	Part VIII.	1904.	0	12	0	0	9	0
	Part IX.	1904.	0	7	0	0	5	3
	Part X.	1904.	0	14	0	0	10	6
	Part XI.	1905.	0	4	0	0	3	0
VII.	Part I.	1904.	0	5	0	0	3	9
	Part II.	1905.	0	6	0	0	4	6
	Part III.	1906.	0	3	0	0	2	3
	Part IV.	1906.	0	7	0	0	5	3
	Part V.	1907.	0	10	0	0	7	6
	Part VI.	1907.	0	4	0	0	3	0
	Part VII.	1907.	0	6	0	0	4	6
	Part VIII.	1908.	0	5	0	0	3	9
	Part IX.	1908.	0	2	6	0	2	0
	Part X.	1908.	0	7	0	0	5	3
	Part XI.	1909.	0	4	0	0	3	0
	Part XII.	1909.	0	12	0	0	9	0
	Part XIII.	1909.	0	5	0	0	3	9
	Part XIV.	1909.	0	6	0	0	4	6
	Part XV.	1910.	0	6	0	0	4	6

2nd Ser. BOTANY.] [VOL. VII. PART 16.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

ANATOMY OF ENHALUS ACOROIDES (LINN. F.), ZOLL.

BY

HILDA M. CUNNINGTON, B.Sc.

(*Communicated by* Prof. PERCY GROOM, D.Sc., F.L.S.)

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

February 1912.

XVI. *Anatomy of* Enhalus acoroides (*Linn. f.*), *Zoll.* *By* Hilda M. Cunnington, *B.Sc.* (*Communicated by* Prof. Percy Groom, *D.Sc., F.L.S.*)

(Plate 36 and 13 Text-figures.)

Read 15th June, 1911.

Contents.

	Page
Introduction	355
The Rhizome	356
The Leaf	359
The Root	363
Male and Female Inflorescences	364
Anatomy of the Bracts	365
Anatomy of the Male Inflorescence	365
Anatomy of the Female Inflorescence	367

Introduction.

Enhalus is a submarine flowering-plant, belonging to the family Hydrocharitaceæ. It occurs below tide-mark along the shores of the Indo-Malayan region from Ceylon to Australia.

The first description of the plant was published by Linnæus fil., under the name *Stratiotes*, the generic name (*Enhalus*) being given by Richard in 1811. Further descriptions have been given by Zollinger, Griffiths, and Ascherson. In addition, Griffiths records the coarser details of the anatomy of the root-stems and leaves, Chatin following with a more detailed but remarkably inaccurate account of the histology. Magnus, in describing the anatomy of the leaves, corrected a number of Chatin's errors. The most complete accounts are given by Sauvageau and Svedelius, the former recording the anatomy of the leaves and the latter the pollination, embryo-sac development, and anatomy of the stem, leaf, root, and peduncles.

Enhalus possesses a stout horizontal elongated rhizome, which is buried in the soil and is attached to it by means of fairly long unbranched roots. The leaves are borne on a close tuft near the stem-apex, which bends upwards. They are long, green, and ribbon-shaped, of length about 2–3 feet and breadth $\frac{1}{2}$–$\frac{2}{3}$ inch, and they are arranged in two lines, namely, one on the dorsal and one on the ventral surface of the stem-axis. Behind the terminal tuft the stem is devoid of leaves, but is covered with a great number of stiff black bristles of various lengths, many being frequently 6 inches long. These are the persistent bast-fibres of decayed leaves. A bud arises in the axil of each of the dorsal, but not of the ventral, leaves. In this, *Enhalus* resembles *Halophila* as described by Professor Bayley Balfour. The rhizome is hence distinctly dorsi-ventral. The arrangement of the roots is not so definite as is the case in *Halophila*, each root

of which arises in the axil of a ventral leaf. The axillary buds of *Enhalus* rarely develop into vegetative shoots, though it does happen sometimes; those that do develop usually give rise to inflorescence-peduncles.

In Hooker's 'Flora of British India,' p. 663, *Enhalus* is described as being monœcious or diœcious. The inflorescences arise in the axils of dorsal leaves, and each is enclosed in two spathe-like bracts. The male inflorescence consists of a number of small flowers on a conical "receptacle." The female inflorescence consists of one flower only.

The Rhizome.

In his account of the various parts of *Enhalus acoroides*, Chatin gives a brief description of the rhizome; but the stem described by him was not that of *Enhalus*, and Magnus, in 1870, suggests that it was probably *Posidonia*. The latter describes the stem as possessing a large central bundle surrounded by dense large-celled parenchyma. Svedelius (1904) briefly describes the anatomy of the rhizome. He states that it has a large cortex, the external layers of which have cutinized cell-walls and are devoid of cell-contents, and within them there are cells with large starch-grains. He describes the endodermis as devoid of starch-grains and without thickened walls, the vascular system as slightly developed, the wood-vessels as being few and not lignified, and he notes the tannin-cells, abundant within the stele, but more scattered in the cortex.

As the descriptions of Magnus and Svedelius show inaccuracies and omissions, an account of the anatomy follows here.

The Rhizome Anatomy.

The surface of the stem is so closely crowded with leaves and leaf-scars, that the distinction into nodes and internodes is obliterated. Hence the epidermis is reduced to irregular interrupted bands and to the region of the actual apex. In the older parts where the leaves have decayed, leaving bristles only, about eight of the outermost layers of the cortex become devoid of contents, and their walls become infiltrated with a dark brown pigment. These walls are not cutinized, for they give the cellulose reaction with iodine and sulphuric acid.

A wide layer of living cortex consisting of parenchyma-cells containing large starch-grains lies within these dead cells. These increase and then decrease in size from the outside inwards. In the dead peripheral cells the intercellular spaces are minute, but in the living cortex they gradually increase in size and then decrease again in passing from the periphery to the stele. In the stem there are no intercellular spaces at all comparable in size or structure with the lacunæ of the root, leaf, or inflorescence-peduncles. Interspersed among the cortical parenchyma-cells, elongated pigment-cells run parallel to the direction of the axis. These, Svedelius describes as tannin-cells; but it was impossible to test the substance, as the material had been transported in alcohol containing iron. It stains deeply with various dyes (methyl-blue, safranin, hæmatoxylin, iodine-green, and eosin), but not with alkannin dissolved in 50 % alcohol. It is insoluble in absolute alcohol, xylol, and water.

The cortex is traversed by vascular bundles from the leaves and roots, those from the former, becoming devoid of bast-fibres, descend obliquely and enter the central cylinder (Pl. 36. fig. 1).

The endodermis is a thin-walled layer of irregular-sized cells, which show the typical cuticular band (Pl. 36. fig. 3, *e*) and do not contain starch. They thus present a marked contrast to the parenchyma-cells without, and the pericycle within, the former containing large and the latter small starch-grains in great numbers. The stele within has the form of a fluted cylinder, so that the endodermis in transverse section presents a sinuous contour.

Fig. 1.

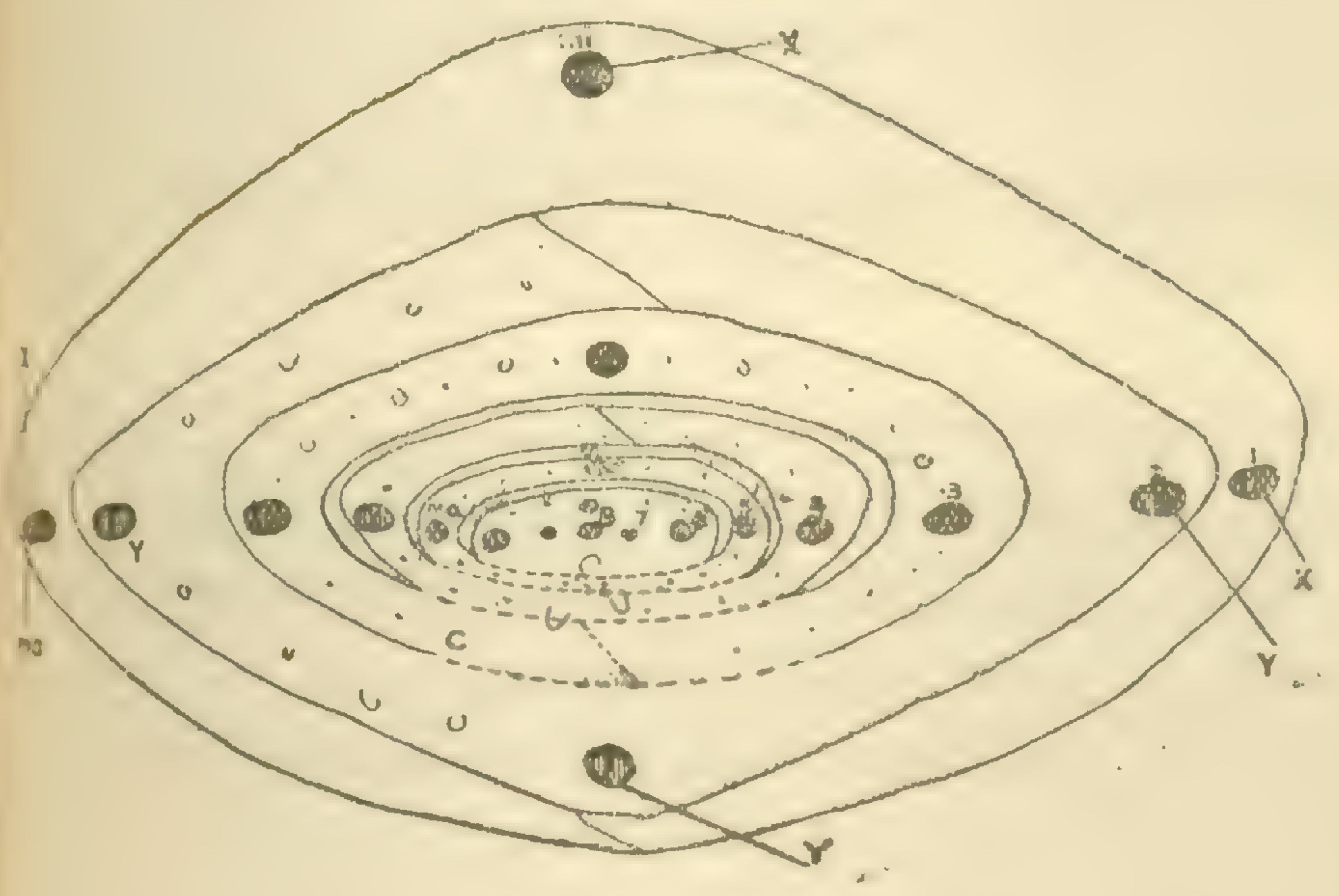


Fig. 2.

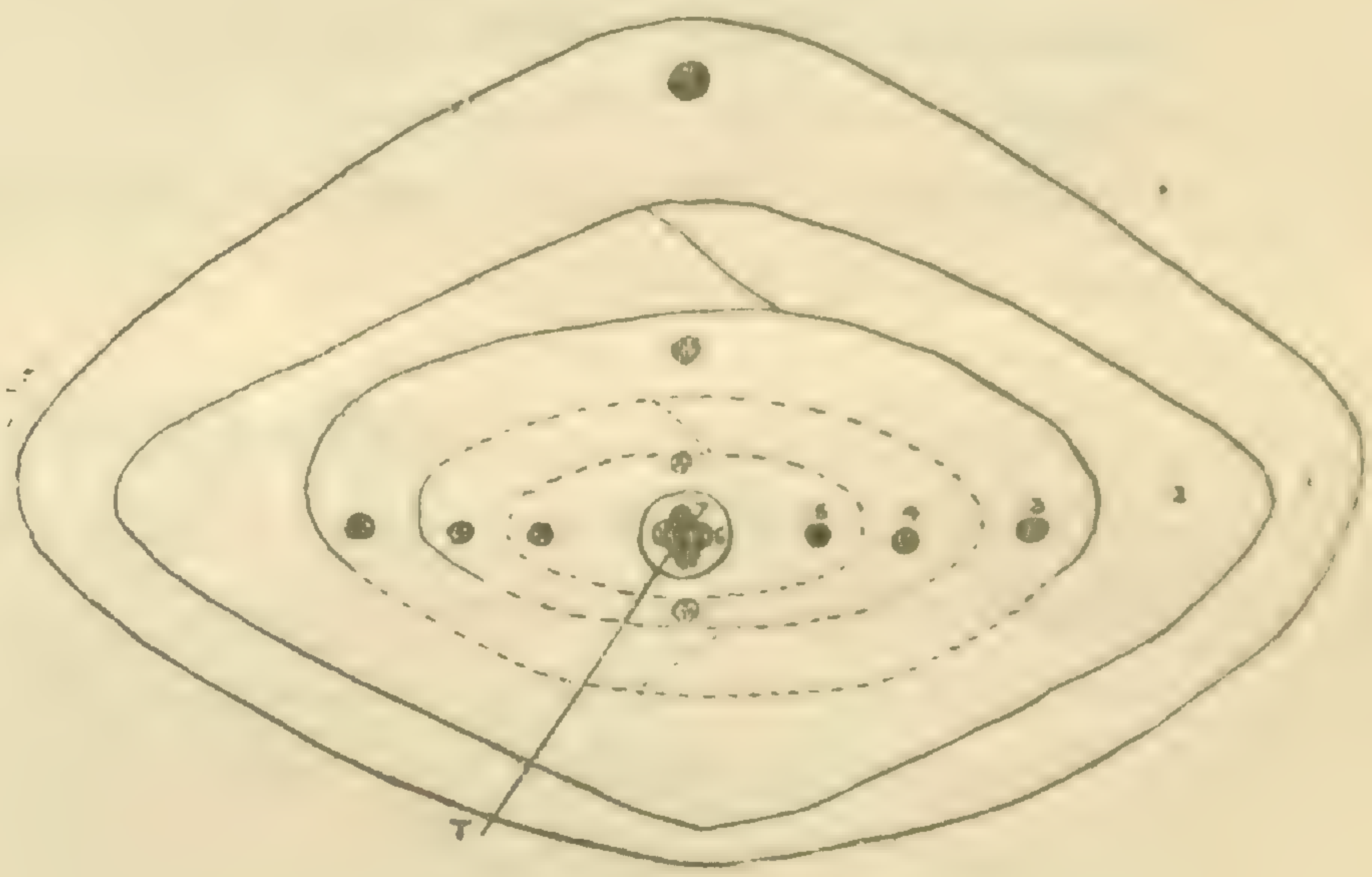


Fig. 3.

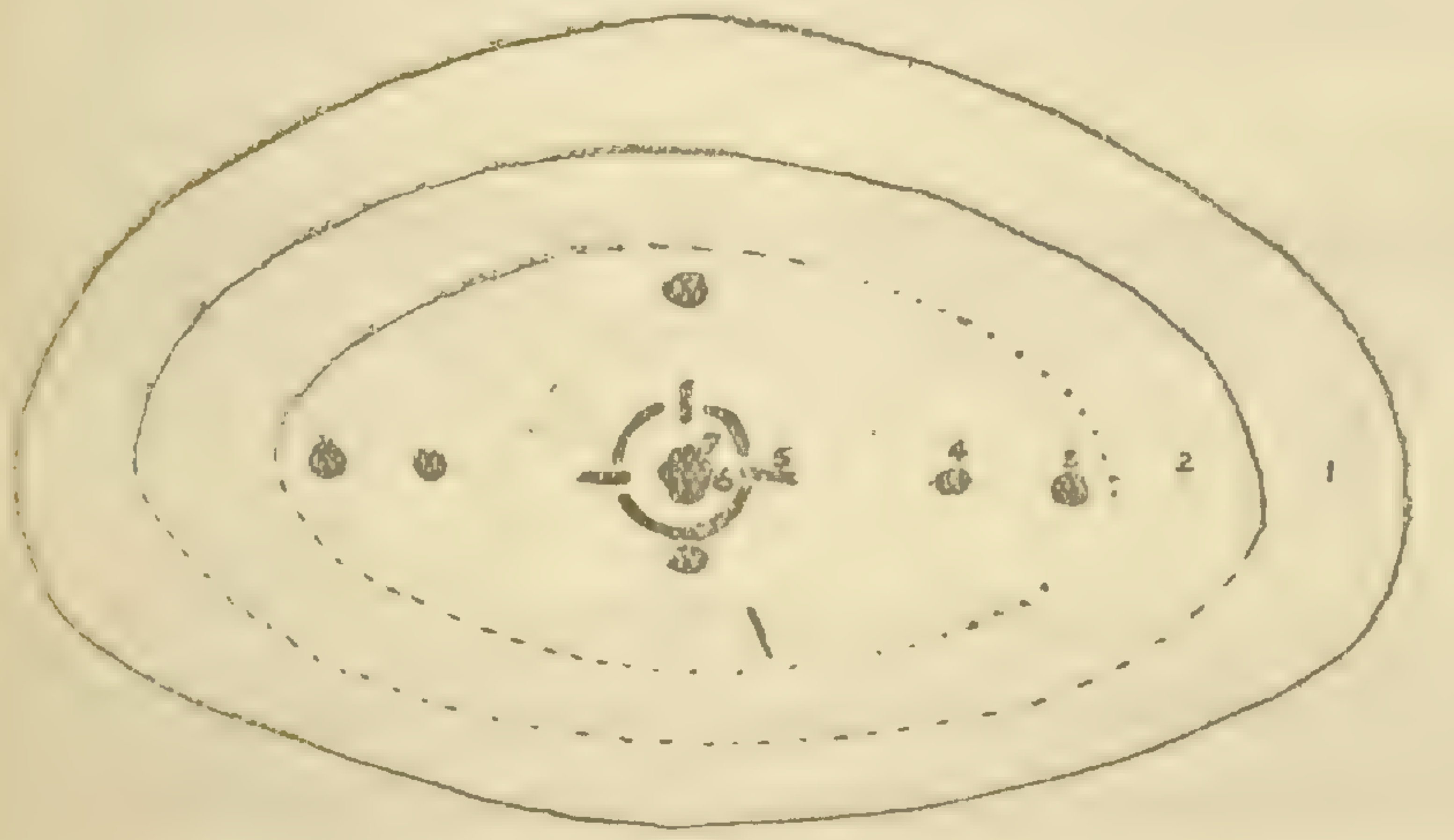
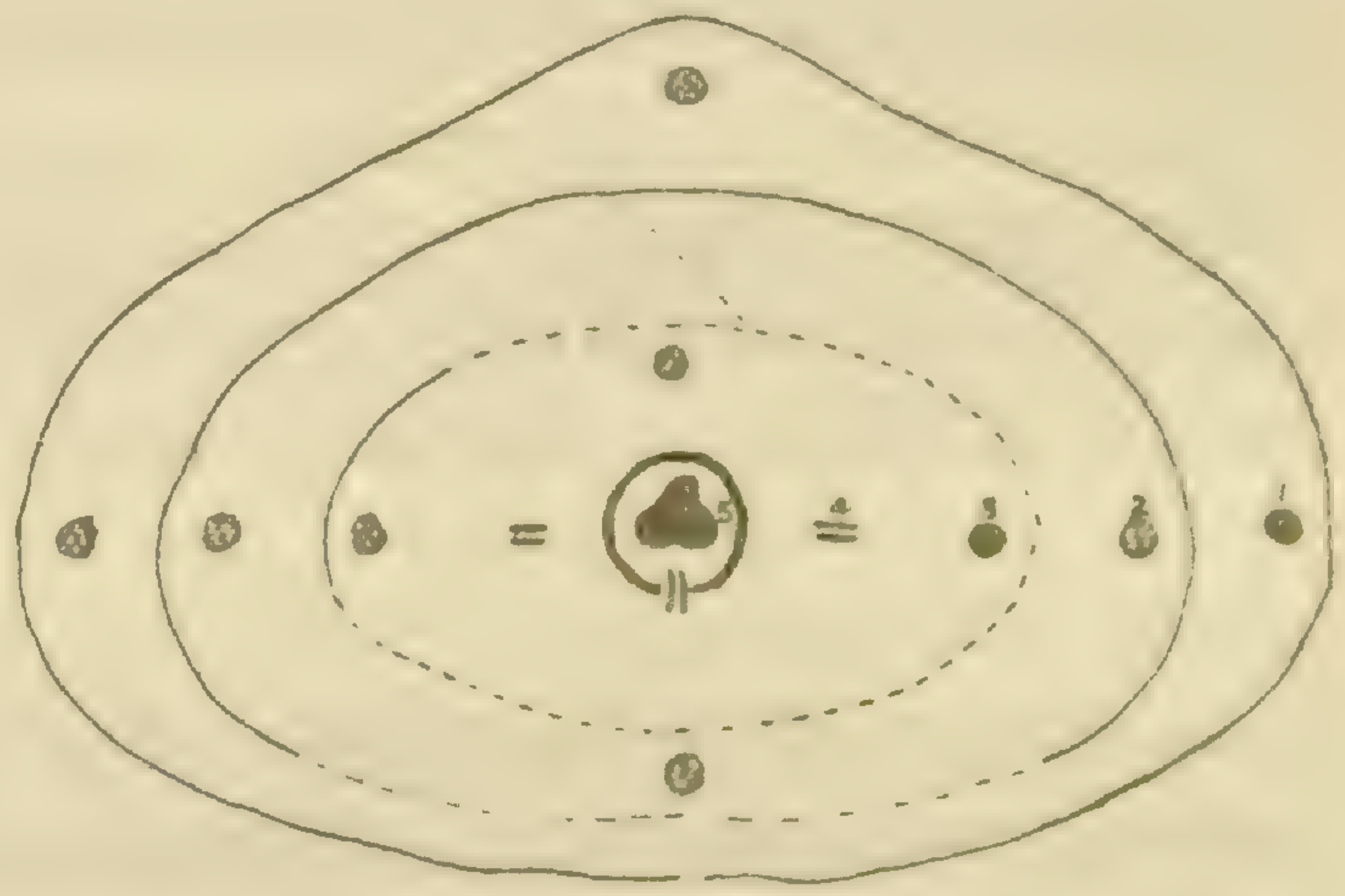


Fig. 4.



The stele (Pl. 36. fig. 1) occupies one-fifth of the diameter of the stem. The vascular system consists of a solid central core of bundles and an outer ring of vascular bundles. The pericycle consists of a single layer of cells interrupted at irregular intervals by the outer ring of vascular bundles. Between the outer ring and the central bundles there is a band of parenchyma and pigment-cells of various sizes, but most of these are elongated in the direction of the stem-axis.

The central bundles are derived from the midrib and marginal bundles of the leaf primarily. As the leaves are arranged distichously and are median dorsal and ventral in insertion, three bundles, two marginal and one midrib bundle, come in from the dorsal side at a time (text-fig. 1, *x*, *x*, *x*), and then a similar three from the ventral side

(y, y, y). When these reach the centre and fuse, a tetrarch-like appearance is produced (text-figs. 1, 2, 3, 4). This shows especially clearly near the apex. The exact arrangement of the inner bundles naturally varies with the level of the section.

The root-bundles, after traversing the cortex, pass through the outer ring and join the central bundles. They usually enter at points midway between the median and transverse planes from both above and below.

The inner bundles do not run straight along the stem, but show an oblique or undulating course; hence, some transverse sections show an apparently irregular arrangement of parenchyma and pigment-cells.

The bundles composing the outer ring all seem to be continuations of the smaller bundles of the leaf. Near the apex these bundles in the cortex are very small and difficult to see, and lower down they enter the stele at a very acute angle, but some of them can be seen fusing with the outer ring some distance below the point at which they enter the cortex.

Structure of the Vascular Bundles.

The outer vascular ring consists of a number of separate bundles containing both phloem and xylem elements. The xylem is usually inwards, so that the bundles are or tend to be collateral, but very often the phloem extends all round the xylem.

The *xylem* (Pl. 36. fig. 3, x) in each bundle consists of 1–6 elements showing well-marked spiral or reticulate thickenings. They follow a sinuous longitudinal course, bending out of the plane of one longitudinal section into the next, but their continuity can be traced. The thickenings do not stain with aniline chloride, and only very slightly with phloroglucin, but they take up iodine-green well after previous treatment with Eau de Javelle. So they are very slightly lignified.

The *phloem* (Pl. 36. fig. 3, p) consists of a few sieve-tubes with well-developed companion-cells which abut externally on the pericycle or endodermis. It may be radially outside or on both sides of the xylem. The phloem develops earlier than the xylem, so that near the apex phloem only can be seen.

The Inner Vascular Bundles.—As the inner bundles approach the centre, their individuality becomes obscured, so that bundles of wood-vessels alone (Pl. 36. fig. 3, w) or wood-vessels accompanied by sieve-tubes lie irregularly arranged in a parenchymatous matrix. In the centre the wood-vessels form a loose anastomosing network, so that many oblique vessels can be seen. In true longitudinal section a longitudinal line of vessels often seems to be interrupted by parenchyma or pigment-cells, the appearance being due to the wood-vessels bending out of the plane of the section. The main mass of intrastelar tissue is formed by the large pigment-cells (Pl. 36. fig. 2, p, fig. 3, t). These are elongated in the direction of the long axis of the stem, but they vary in shape.

The apex of the stem is bent upwards slightly. Here the epidermis completely surrounds the stem and consists of cells of irregular size. The young leaves and intravaginal scales arise very near to the apex, and the leaf-bundles, at first consisting of phloem only, enter and pass into the centre. The endodermis is not developed in the younger parts of the stem, being visible only when the outer ring of bundles is fully developed.

The Leaf.

Accounts of the leaf have been given by Griffiths, Chatin, Magnus, and Sauvageau. Griffiths described correctly the coarser features of the anatomy (Chatin gives a description of the leaves of a plant under the name of *Enhalus*, but his figures do not accord with the structure of the leaf of *Enhalus*); Magnus added further details, especially showing the diminution in the number of vascular bundles towards the apex. The most complete account is given by Sauvageau, and is summarized as follows:—The leaves are long and ribbon-shaped, with a sheathing base, the sheath dwindling to a mere line on the side away from the insertion, and are traversed by parallel veins. The whole is surrounded by an epidermis, but the internal structure varies at different heights. In the middle portion the mesophyll consists only of one subepidermal layer of parenchyma on the dorsal and ventral sides. Between these there are numerous rectangular air-chambers composed of long lacunæ separated by sheet-like trabeculæ of parenchyma one cell thick, at right angles to the dorsal and ventral surfaces, and running the longitudinal length of the leaf.

At regular intervals the lacunæ are spanned by transverse diaphragms composed of one layer of much smaller parenchyma-cells, and separated at the angles by small intercellular spaces. Pigment-cells occur in the subepidermal tissue and trabeculæ. Parallel vascular bundles run the longitudinal length of the leaf. In position they correspond to the trabeculæ, one bundle running in the tissue at the abaxial or adaxial region of the trabecula (Pl. 36. fig. 14). The longitudinal bundles are hence in two series in the adaxial and abaxial subepidermal tissues respectively. In most cases the two series run in alternate trabeculæ, but occasionally in the same one. In both systems, however, the phloem lies on the side towards the epidermis and the xylem on the side towards the centre of the leaf. The abaxial longitudinal veins are connected by transverse bundles which run parallel to the epidermis in the diaphragms, which here become more than one cell thick. The longitudinal bundles are not all the same size, the midrib and marginal ones being markedly larger. Near the apex their number decreases.

Near the base of the leaf the abaxial subepidermal tissue is from five to six layers thick, and the trabeculæ and air-chambers are limited to the adaxial side of the leaf. There is also only one system of vascular bundles here, the abaxial system. Sauvageau explains the nature of the adaxial system in the following words:—"Elle provient . . . . de ce que certaines des nervures transversales d'anastomose, au lieu de réunir deux nervures normalement orientées, se sont dirigées vers la couche sous-épidermique de la face opposée, puis se sont relevées suivant la longeur de la feuille pour devenir des nervures parallèles aux premières."

To this description the following amplifications and corrections may be made:—At the base of the leaf the intercellular space system is gradually obliterated by: (1) the encroachment of abaxial parenchyma (Pl. 36. fig. 4, ①); (2) the less-marked multiplication of the adaxial parenchyma (fig. 4, ②); (3) by the division of the trabecular cells, so that the trabeculæ become a mass instead of layer of cells (fig. 4, ③); and (4) by the adjacent trabeculæ becoming connected by rows of cells arranged parallel to the leaf-surface and at right angles to the trabeculæ (fig. 4, ④).

The fibrovascular bundles consist mainly of bast-fibres with walls that thicken relatively late (fig. 4, *b*). As the leaves age and disintegration sets in, the walls of the fibres become impregnated with brown colouring-matter, and a number of these persist as the bristles so prominent on the leafless parts of the rhizome. But even in this condition the walls are not lignified (though Sauvageau states to the contrary); they give a blue coloration with iodine and sulphuric acid, and do not stain with phloroglucin and hydrochloric acid.

Within the bast-fibres a small amount of phloem lies, being represented by several sieve-tubes with companion cells. The xylem lies within this. Sauvageau states that the xylem is represented by a vascular lacuna only, but in this space lie spiral or reticulate vessels, of which one to five are always present in the larger bundles. One or two vessels are present in the smaller ones, though here they are occasionally absent.

The epidermis is devoid of stomata and has a thin cuticle.

Fig. 5.

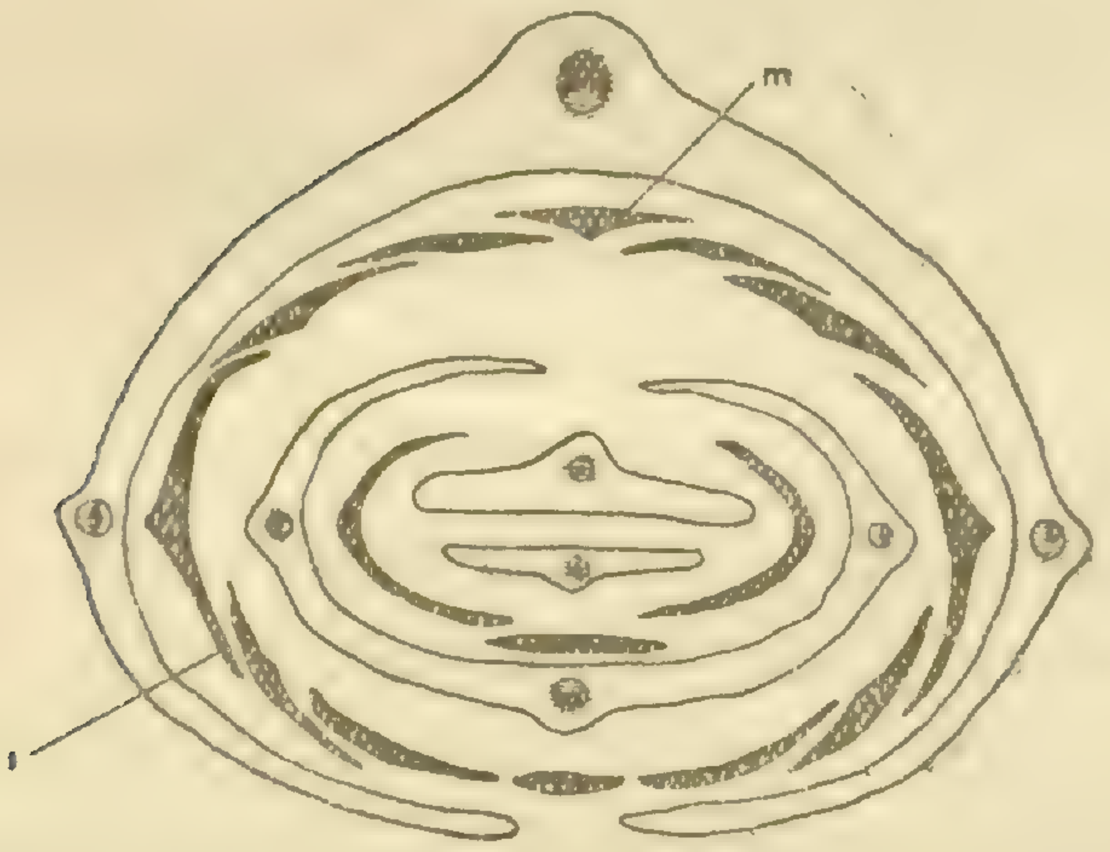
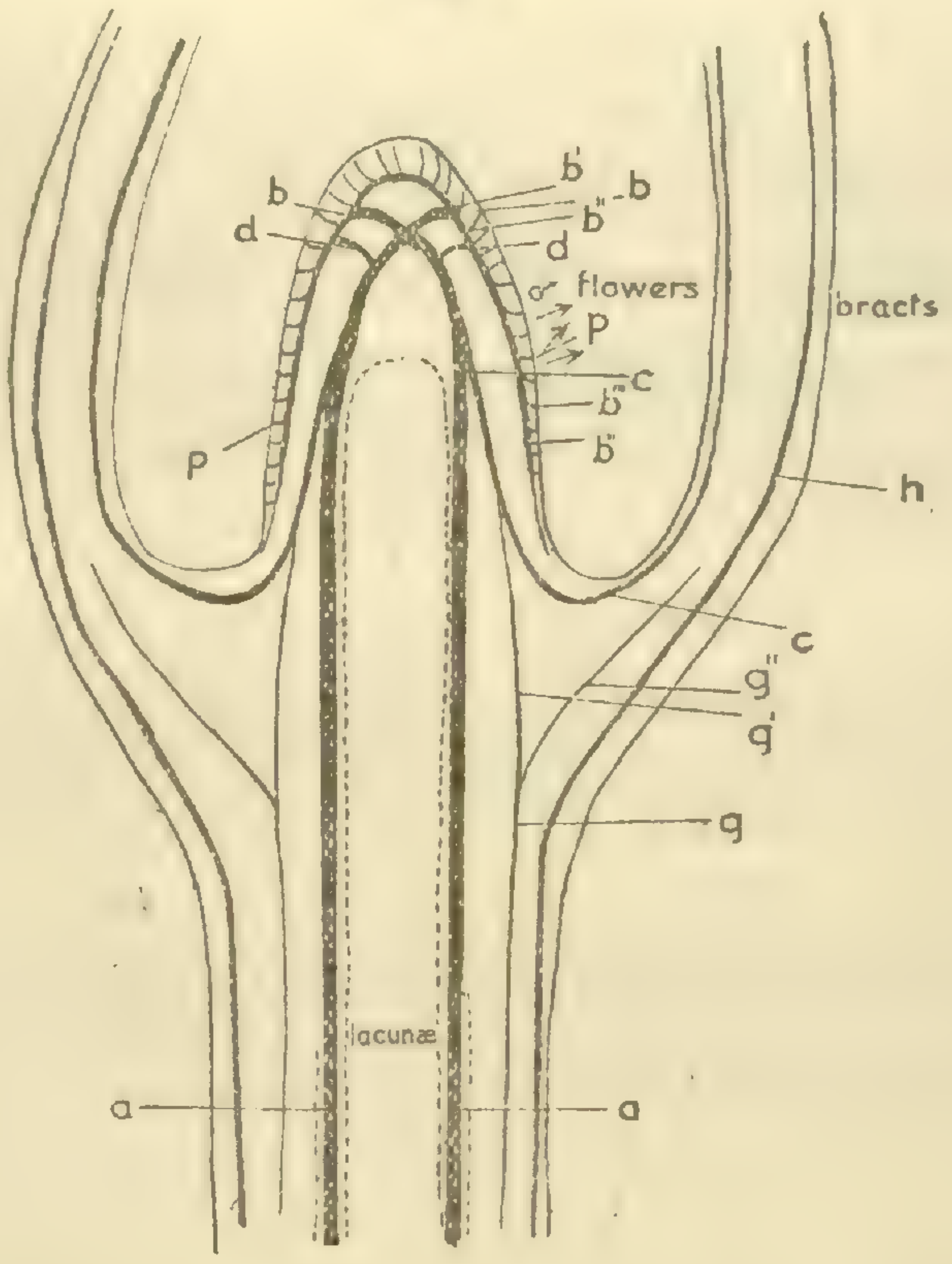


Fig. 6.



Between the leaves there are numerous strap-shaped intravaginal scales. These arise very early, and can be seen within the youngest leaf-primordia near the growing apex. There are usually ten to twelve intravaginal scales to each leaf arranged in a definite manner (text-fig. 5, *i*). One median scale lies on the median axil of the leaf (text-fig. 5, *m*), and the rest are arranged in descending æstivation. They consist of parenchyma with scattered pigment-cells (Pl. 36. fig. 5).

Aeriferous System.

Sauvageau describes the origin and development of the aeriferous chambers and diaphragms in *Zostera*, and says that the account applies to *Enhalus acoroides*. He did not, however, describe the earliest or most interesting stages or the development of the bundles. For this reason a complete description is given here.

The leaf arises as a horseshoe-shaped hump near the apex of the stem. The fully

developed air-chambers can be traced from the earliest stage, when the leaf consists of one flat layer of mesophyll-cells surrounded by an epidermal layer (Pl. 36. fig. 6). This stage is important, as the air-chambers formed are equal in number to these cells. Each cell of this layer divides by walls parallel to the epidermis four times, so that from each original mesophyll-cell a column of five is produced (Pl. 36. fig. 7, *col*). The four adaxial cells in each column cut off a small cell towards one side, and then later a similar one towards the other side, by walls at right angles to the epidermis and parallel to the length of the leaf, so that two columns of narrow cells are formed between the columns of wide cells (Pl. 36. fig. 8, *d*). The small cells then divide by walls in the direction of the length of the leaf, producing plates of small cells which are the diaphragms of the older leaves (Pl. 36. fig. 9, *d*). The remaining wide cells then each divide in half by a wall at right angles to the epidermis, but parallel with the breadth of the leaf, forming two cells from each. These increase in size, thus separating

Fig. 7.

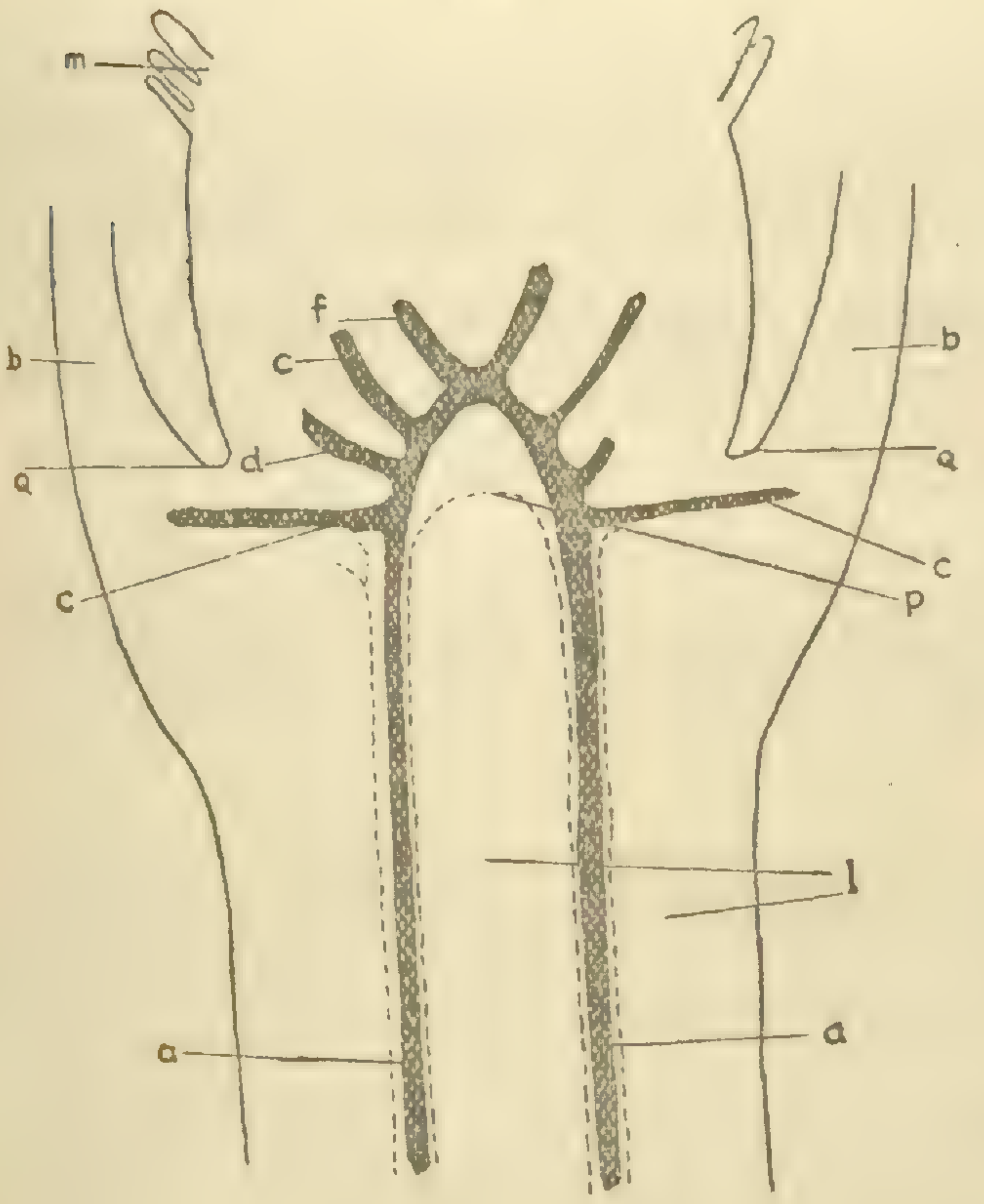
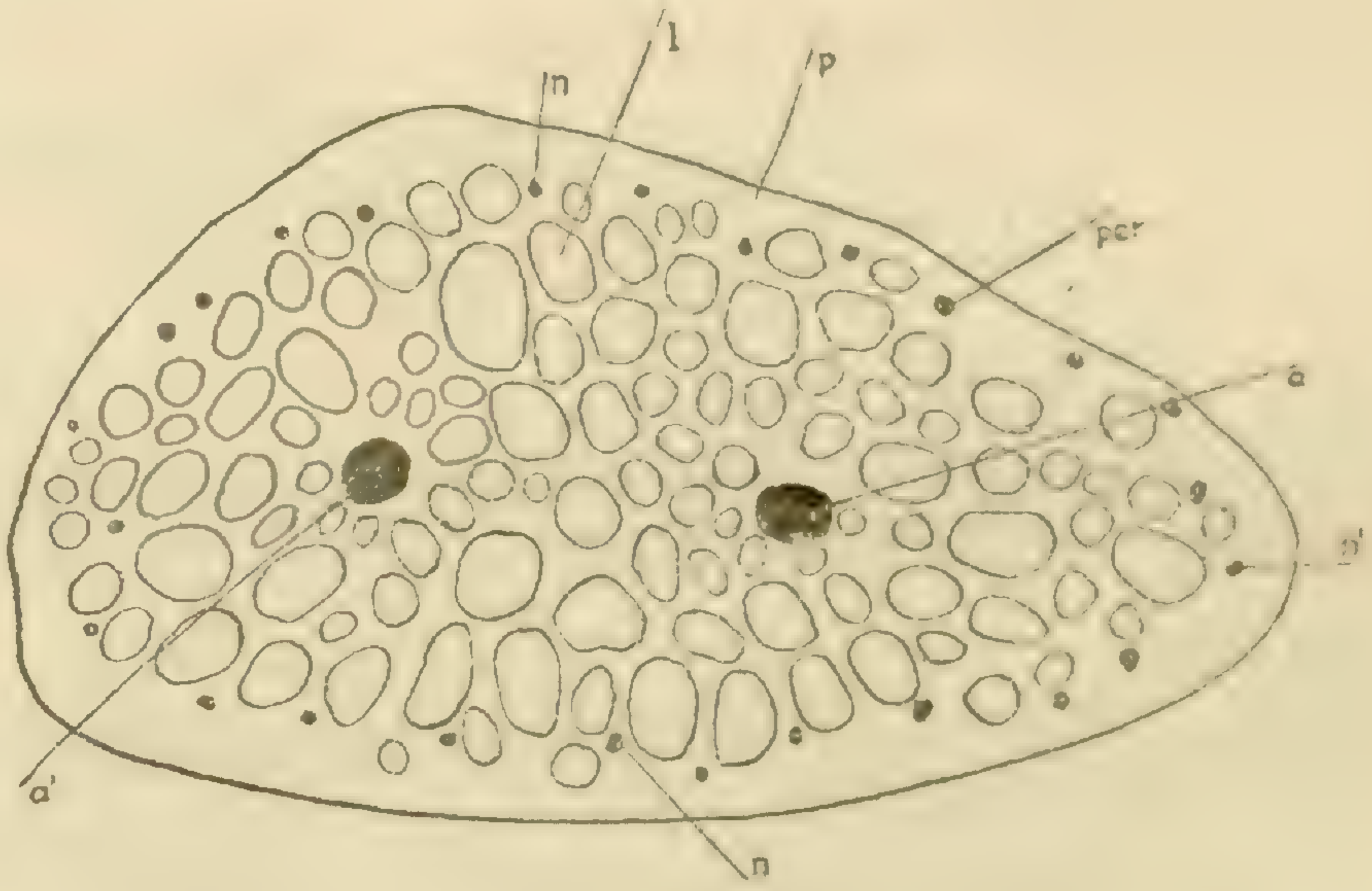


Fig. 8.



the diaphragms and forming air-spaces. Further divisions of a similar nature then take place, enlarging the air-spaces longitudinally until they appear as long narrow lacunæ (Pl. 36. fig. 10, *l*) spanned at regular intervals by diaphragms (fig. 10, *d*).

It is interesting, as was discovered by Professor Groom, to note that each space with the diaphragm-cells at one end and the trabecula-cells between that diaphragm and the next is equivalent to one of the original primary mesophyll-cells. So the number of air-chambers in the mature leaf is determined from the beginning.

The abaxial cells of the original columns, except when a bundle is to be formed, divide into one-half or one-third by walls at right angles to the epidermis and parallel with the length of the leaf, forming a continuous subepidermal parenchyma.

The Vascular System of the Leaf.

The development of the small bundles is easiest to trace, as the large bundles develop much earlier and rarely show very early stages.

The abaxial cells of the trabeculæ give rise to the bundles. In transverse section the following sequence of cell-division is shown in the formation of a bundle:—Each of the long row of cells (parallel with the length of the leaf), which is about to produce a bundle, divides by two walls at right angles to the epidermis and parallel to the length of the leaf, thus dividing each cell into three (Pl. **36.** fig. 8, *b*). The central one of these then divides into two by a similar wall. These two inner cells (Pl. **36.**

Fig. 9.

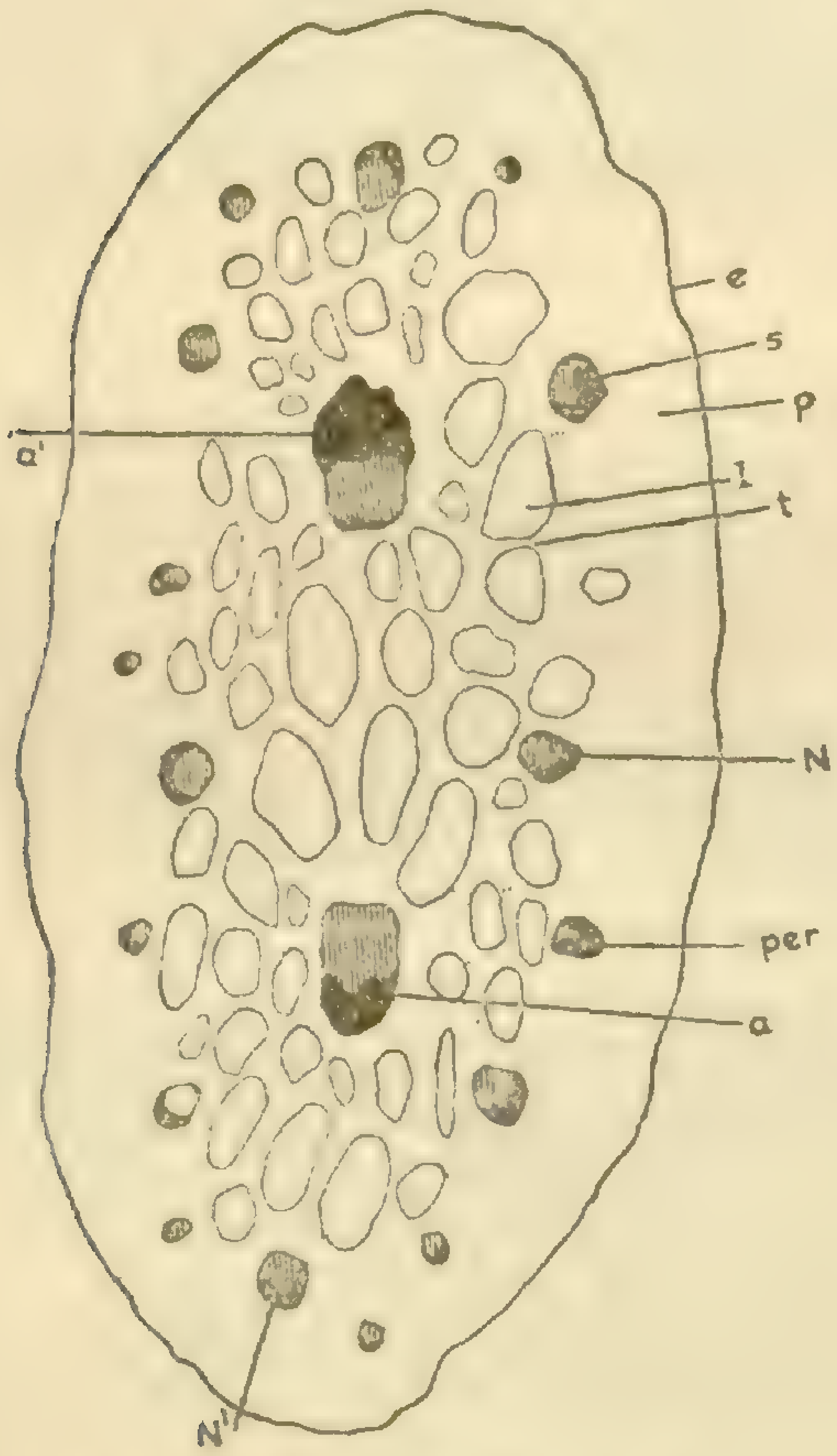


Fig. 10.

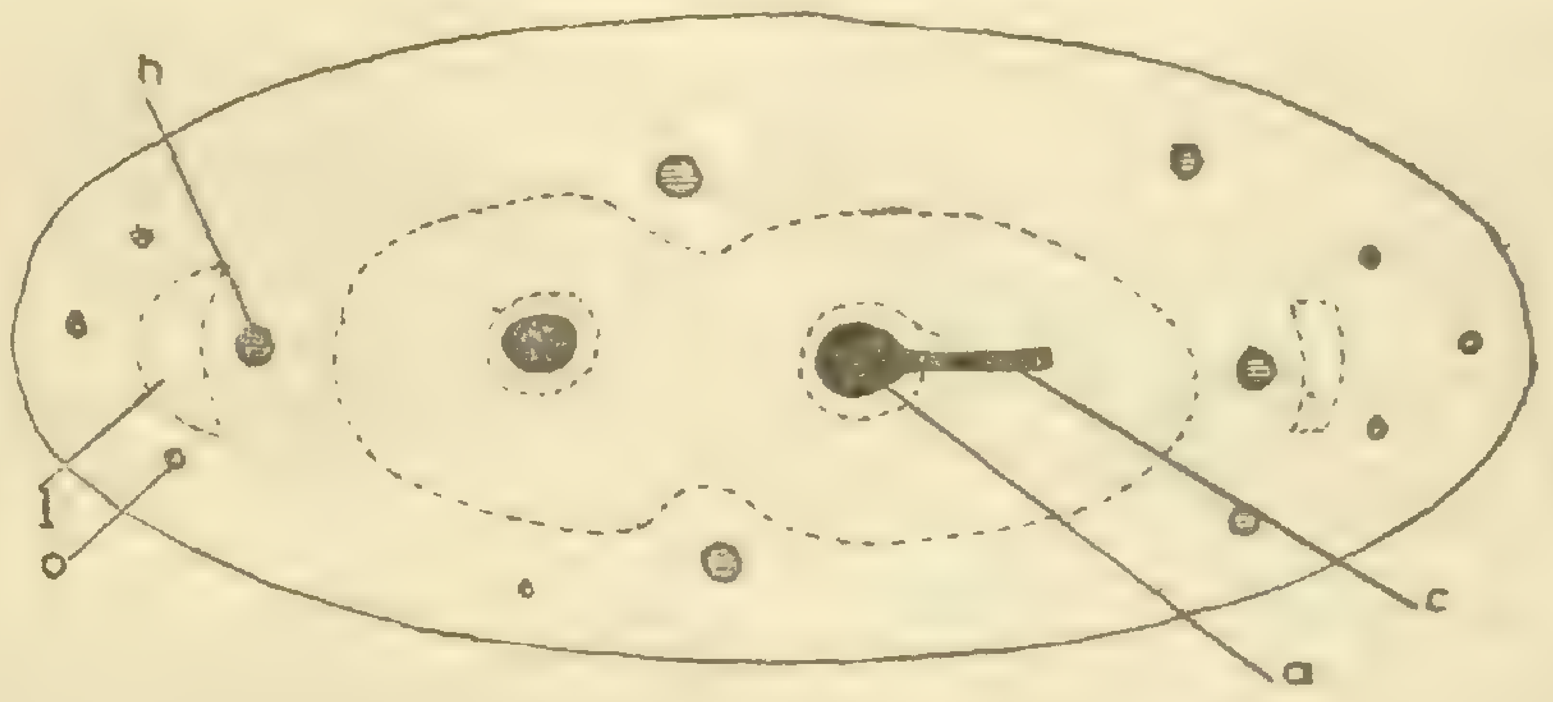


fig. 11, *a'*, *a''*) so formed divide by walls parallel to the epidermis, forming six cells (Pl. **36.** fig. 12, *c*); and these with the two original end-cells, by further division in various directions, form the primordia of the bundle (Pl. **36.** fig. 13, *p*), which elongate, forming the xylem, sieve-tubes, and parenchyma.

The bundles arise in every alternate trabecula; thus there are twice as many air-chambers to be seen in transverse section as there are bundles. As the leaf grows in the basal region, and the midrib and marginal bundles become larger, the trabeculæ below these divide and the cells separate, forming two extra air-chambers below them, so that there are six extra air-chambers in the leaf.

Pigment-cells.—In the leaf there are three different kinds of pigment-cell in three different tissues:—

(1) In the trabeculæ the pigment-cells are of the same size and shape as the parenchyma-cells of the trabeculæ.

(2) In the subepidermal parenchyma elongated pigment-cells like those of the cortex of the stem are present.

(3) In the bundles very much elongated narrow tubular pigment-cells.

In the intravaginal scales the pigment-cells are of the same size and shape as the other parenchyma-cells composing them.

The Root.

The most accurate description of the root has been given by Svedelius. He shortly describes it as a normal root-structure, and gives the following details:—The epidermis has very few root-hairs, functions only at a very early stage, and is separated from the outermost layers of the cortex by an exodermis. The other cells of the cortex are arranged in radial layers with intercellular spaces. In the external part large air-chambers separated by radial rows of tissue arise. The central cylinder occupies but a small part of the whole scheme of the root, and is surrounded by a slightly developed thin-walled endodermis. The xylem consists of very few unlignified feebly developed vessels; the phloem is relatively better developed. Tannin-cells are present, except inside the endodermis.

The following account is more detailed and records several interesting facts not observed by Svedelius:—

The root of *Enhalus* shows the typical structure of a monocotyledonous aquatic plant. The epidermis only persists as a many-layered root-cap. On the outside of the root there is a crushed layer of cells of hardly distinguishable structure (Pl. 36. fig. 15). The cortex surrounding the small central vascular cylinder is differentiated into three zones, the outer, middle, and inner respectively. The outer cortex consists of six layers of cells, of which the outer two form a thin-walled exodermis with no apparent intercellular spaces. These cells are radially elongated and have darker-coloured walls as compared with those radially on either side. The four inner layers of this zone have thicker walls than the exodermis and small intercellular spaces. This zone contains pigment-cells.

The middle and the inner cortex resemble each other when young, except that the inner cortex possesses pigment-cells. They consist of thin-walled cells in radial and concentric rows. It follows from this arrangement that square intercellular spaces, also presenting a radial concentric appearance, are formed at the corners between each four cells and are larger towards the outside, here equalling the cells in size. As the root gets older the middle and the inner cortex become differentiated, the middle being a wide band ($2\frac{1}{2}$ times the width of the outer cortex) becomes composed largely of aeriferous tissue. First, the outer layers split in the intercellular space-lines, forming large radial lacunæ of irregular size and shape. Later on, the radial walls of all the cells in this zone collapse together, thus (Pl. 36. fig. 15) forming large intercellular spaces separated by long double rows of radial cell-walls. After leaving the apical meristem the middle and the inner cortex-cells become elongated vertically, and are crossed by diaphragms at irregular intervals. The latter consist of single layers of cells which are in contact with one another, and which remain rounded when the other cortical cells elongate. They appear spirally arranged, but the spirals are limited in length and can only be traced for a short way round the cortex in any series of transverse sections.

The endodermis-cells are radially the innermost layer of the inner cortex, the cells of which remain radially arranged throughout the life of the plant, and can be distinguished from the latter by the presence of the characteristic radial dot.

The root-bundle is exarch and usually hexarch, though it is sometimes pentarch or

heptarch. The pericycle consists of one layer of thin-walled cells. Within it 5–7 large spiral vessels lie on the outside of a solid mass of poorly lignified xylem. The large vessels show up after treatment with Eau de Javelle. The phloem, which is hard to distinguish, lies in the bays between the primary xylem-groups.

The young roots arise well out in the cortex of the rhizome, very close to the growing point. The endodermis here cannot be traced, but the origin of the root is halfway between the outside of the rhizome and the outer ring of vascular bundles round which the endodermis lies in the older parts of the stem. Their origin is hence semi-endogenous.

Male and Female Inflorescences.

The whole of the external morphology of the inflorescences has been well described by Svedelius, but the anatomy of the peduncles only has been described by him. So a short recapitulation only of the external morphology is necessary before dealing with the anatomy.

Both the male and female inflorescences are borne on peduncles arising in the axils of the dorsal leaves of the stem-axis. In each case the inflorescence is enclosed in a spathe consisting of two bracts.

The external characters of these bracts differ in the male and female, but their internal structure is very similar. The external structure, with the exception of the arrangement of the mucilage-papillæ, has been described by Svedelius. In the male the bracts are "widely ovate-lanceolate and keeled"; their length does not exceed 5 cms. and their breadth is 3 cms. or a little more. One overlaps the other at the base with both margins. Along the midribs and marginal veins there are long mucilage-producing hairs, those down the midrib consisting of four irregular longitudinal rows, while those down the marginal veins consist of one row only. The female bracts when fully developed are "narrow and oblong" and not greater than 2 cm. in breadth. They are "stiffly keeled" and bend back, leaving the female flower exposed. There is a wide band of mucilage-producing papillæ consisting of four irregular longitudinal rows down the midrib only. These papillæ, present on both the male and female bracts when young, are simple and unbranched. When old, and especially in the fruit, they show a branched structure with a broad base, in most cases presenting the appearance of a number of the unbranched ones fused at the base. The apex is club-shaped when young, but becomes pointed when older. In structure they are parenchymatous and multicellular. Towards the apex they become narrower and terminate in a single cell (Pl. 36. fig. 16), which is pointed, has a thick wall, and contains mucilage which stains with Hanstein's violet and Ruthenium red, but not with Congo red; it is thus pectic in nature. The papillæ contain a few tannin-cells.

In both the male and female inflorescences there are intravaginal scales, the arrangement of which, however, is not clear.

In the male inflorescence above the point of insertion of the bracts the inflorescence-peduncle is prolonged into a tongue-shaped "receptacle" bearing a large number of male flowers. These are borne on pedicels six times the length of the flower. The

flower has 3+3 perianth-leaves (sepals and petals) and 3 stamens, all free and in three alternating whorls.

Each stamen consists of a short stout filament bearing two large bilocular anther-lobes, each loculus of which contains from 7 to 14 large pollen-grains.

In the female inflorescence the peduncle is prolonged, and the flower arises just above the point of insertion of the bracts. There is one epigynous female flower composing the whole inflorescence. It has 3+3 free perianth-leaves and a syncarpous unilocular inferior ovary with from 6 to 8 carpels. On the outside this is concealed by mucilage-producing papillæ of structure similar to those on the bracts. The ovules are anatropous and inserted at different levels in different carpels.

Anatomy of the Bracts.

The bracts resemble the leaf generally in structure, but clearly show outstanding differences in transverse section. The structure varies at different levels, at the apex resembling that of the leaf more or less and at the basal region bearing a resemblance to that of the peduncle from which it gradually differentiates.

As in the leaf, there is an epidermal layer, while the space between the dorsal and ventral faces is occupied by lacunar tissue. According to the level, there are from one to several subepidermal layers of parenchyma. Near the base there are from one to several layers on the adaxial and abaxial side respectively; higher there are one or two layers both adaxially and abaxially. The lacunæ in the basal region are irregular in size and shape, the trabeculæ running obliquely, longitudinally, or horizontally, and not all at right angles with respect to the dorsal and ventral surfaces as in the apical region of the bract and in the leaf. At irregular intervals transverse diaphragms, one cell thick, span the lacunæ.

The vascular bundles run in the ends of the trabeculæ as in the leaf. There are a large median and two "marginal bundles," which arise as branches of the central median bundles of the peduncle. The large median bundle, however, is on the adaxial side of the bract, and a small bundle only is on the abaxial side. Between the median and marginal bundles there are smaller bundles of two sizes, alternately larger and smaller, on the abaxial side of the bract. Near the apex these send anastomosing branches to the adaxial side as in the leaf. The structure of all these bundles is the same as that of the leaf-bundles. When old those in the female inflorescence show much thickened bast-fibres, but in the male very little had arisen in the oldest specimen examined.

Anatomy of the Male Inflorescence.

The Peduncle.—In transverse section the shape is elliptical. Surrounding the peduncle there is a well-defined epidermis, outside which there is a delicate cuticle. The epidermal layer consists of regular cells, the outer walls of which are much thickened and show definite layering after treatment with Eau de Javelle.

Within the epidermis there is a band of continuous parenchyma (text-fig. 8, *p*) with no lacunæ. This layer, 2 to 3 cells thick, surrounds lacunar tissue (text-fig. 8, *l*) which, except for two vascular bundles (text-fig. 8, *a*, *a'*), fills the centre. The lacunæ are

elongated passages, considerably larger in area than the parenchyma-cells of the trabeculæ separating them, and are irregular in size. At irregular intervals these are spanned by horizontal and occasionally longitudinal diaphragms one cell thick.

The vascular system is bisymmetric, and consists of two large bundles situated at the points of trisection of the long axis of the ellipse (text-fig. 8, *a*, *a'*) and an ellipse of small peripheral bundles, 28–30 in number, in the continuous peripheral parenchyma, all of which anastomose frequently with each other. The former may be known as the median and the latter as the peripheral bundles. The two peripheral bundles near the ends of the short axis of the ellipse are slightly larger and nearer the centre than the rest of the bundles (text-fig. 8, *n*, *n*).

All the bundles are oriented with their xylem inwards and present the same structure as the bundles of the leaf, except that the phloem prosenchyma is never thickened. This peduncle retains the same structure throughout its life. In the large central bundles there are two or three spirally thickened vessels which are hard to distinguish in many places.

In some sections the bundles have a bicollateral appearance, due to the arrangement of the parenchyma-cells.

Very few tannin-cells are present.

The Inflorescence (text-fig. 6).—The two median bundles (text-fig. 7, *a*, *a*) run upwards parallel until they reach a point two-thirds of the length of the tongue-shaped receptacle; here they bend and, forming an arch, fuse at the top (text-fig. 6).

At the bend each median central bundle gives off three bundles, one of which (*c*) bends obliquely down in the median plane till it reaches the point of insertion of the bracts. Here it bends up and runs up the adaxial side of the bract, forming the large median bundle of the bract.

The two other branches of the central median bundle, from the same point, bend laterally obliquely down and up again, forming the marginal bundles of the bracts.

The fusion-bundle at the top of the arch emits about 30 small branches (the two median ones, *b*, *b*, being shown in the figure), which ascend obliquely outward. Each of these divides into two (*b'*, *b''*); one branch (*b'*) ascends, and meeting fuses with the remaining 29, while the other branch (*b''*) bends down and descends to the point of insertion of the bracts. From these branches (*p*) arise and run outwards into the pedicels of the male flowers, one branch to each pedicel.

Halfway between the bend and the terminal fusion of the median central bundles each emits a large median branch (*d*), which passes obliquely upwards and outwards for a short distance and fuses with the descending branch (*b''*) of the median bundle from the top.

Below the insertion of the bracts a median bundle (*g*) between the central and peripheral bundles divides into two branches (*g'*, *g''*), one of which (*g'*) passes up into the "receptacle" and fuses with the descending large median bundle destined to become the median adaxial bundle of the bract. The other (*g''*) passes straight up into the bract, and could be traced no farther. Here also the peripheral bundles of the peduncle anastomose among themselves and pass straight up into the bract and form the smaller

bundles of the bract; the small median peripheral bundle of the peduncle continuing as the median abaxial bundle of the bract.

The bract-bundles, in common with the leaf, have their median and marginal bundles derived from the central vascular system, while the smaller ones arise from the peripheral bundles.

The Pedicel.—The pedicel, though cylindrical, is dorsiventral in structure and consists of two external rings of parenchyma-cells (Pl. 36. fig. 17, *p*), surrounding two lacunæ (Pl. 36. fig. 17, *l*) (separated by a trabecula, *t*), which run the whole length of the pedicel till just below the flower, where they become obliterated by transverse septa. At the end of the trabecula which lies on the posterior side the single vascular strand runs from the peduncle to the flower (*vb*). Just below the flower it bends from a lateral into a central position. It then divides into three branches, which pass up the filaments of the stamens. The structure of the vascular bundle is the same as that of the leaf, and in the same manner the xylem (1–3 spiral vessels) is directed inwards. There is no other thickening. The parenchyma-cells surrounding the lacunæ are twice as long as broad, except at a zone a little way below the flower, where the cells are rounded. Here also there are no tannin-cells. This Svedelius states is the region of detachment of the male flower when it is freed.

The Flower.—The perianth-leaves are in two whorls, sepals and petals showing various differences in structure. The sepals and petals are very similar when young, consisting of an epidermis and parenchyma-cells, of which there is only one layer near the margin, but in the middle there are 3–4 layers in the sepals and 1–2 in the petals. In the sepals there are numerous long tannin-cells near the median line running longitudinally. In the petals there are only a few tannin-cells. When the flower is older every cell of the inner upper epidermis of the petals grows out into a projecting papilla.

The anthers when young are surrounded by two similar cell-layers, the outer of which develops every cell into a projecting papilla when older. These papillæ (Pl. 36. fig. 18, *pp*) interlock with either those of the adjacent anthers or petals, so that the whole is held firmly together and is air-tight. In each of the four loculi of each anther only eight spore mother-cells are formed; they are in a longitudinal column, and in transverse section one only is seen. Some of these divide forming a tetrad of pollen-grains; but these do not develop, as there are from 7–14 pollen-grains only in each loculus out of a possibility of 32 (Pl. 36. fig. 19, *l*).

The pollen-grains, when young, are spherical in shape. When older, in alcohol material they are very wrinkled, but the wrinkling may probably be a result of fixation in alcohol, as no one else mentions it as a peculiarity. They contain three nuclei when ripe.

Anatomy of the Female Inflorescence.

Peduncle.—When young the female peduncle resembles the male in general structure, but subsequent to fertilization considerable differences appear. These are due to alterations in structure in the female peduncle which cause it to coil up into a tight spiral.

The young peduncle (text-fig. 9) shows the same general structure as the male, but there are certain differences by which a female peduncle is easily recognized. The elliptical transverse section is not so elongated and the subepidermal parenchyma (*p*) is 6–8 cell-layers thick as compared with 2–3 in the male. The vascular bundles are arranged in the same manner, but there are only 16 peripheral bundles (*per*), which are much larger than the corresponding ones in the male. Though, as a rule, they are situated at the ends of the radial trabeculæ separating adjacent lacunæ, there are exceptions caused by secondary division and separation of cells radially outside the bundles forming supernumerary lacunæ there. In the female the bundles at the ends of the median axis (x′) are larger and nearer the centre than the rest. Their structure is exactly like those of the male.

Subsequent to fertilization the following changes take place in the peduncle :—

The outer walls of the epidermal cells become infiltrated with tannin, and tannin accumulates in many of the parenchyma-cells just within. The bundles increase in size, but this increase does not take place equally in all the bundles. Throughout the peduncle the increase in one of the central bundles (*a*′) is greater than in the other (*a*); the phloem-prosenchyma becomes strikingly thickened, though still consisting of cellulose as in the leaf. The arc of thickened bast-fibres of the larger bundle (*a*′) is larger than that of the smaller (*a*). In several cases there were thickened fibres in the inner side of the former also, which were most apparent in sections through the spirally coiled part of the peduncle. In one case the bast-fibres extended inward, embracing the soft phloem on one side, but not on the other. In another the peripheral bundles on one side were more thickened than those on the other.

Svedelius says that the structure is at this stage monosymmetric.

The Vascular System of the Inflorescence (text-fig. 7).—Just below the inflorescence the peduncle becomes longer and narrower in transverse section, owing to the development of the bracts (text-fig. 10). Below the point of insertion the peripheral 2–4 bundles of the peduncle near the two ends of the ellipse branch, and these branches (text-fig. 10, *o*) ascend obliquely outwards, higher up they form an arc of bundles outside the general ring of peripheral bundles. The parenchyma, immediately within each arc and separating it from the general ring of bundles, becomes lacunar, the lacunæ (text-fig. 10, *l*) having much the same relative position to the bundles as they do in the leaf. The original peripheral bundles (*h*) of the peduncle slightly higher up bend outwards, anastomosing with this new outer system of peripheral bundles passing into the bracts.

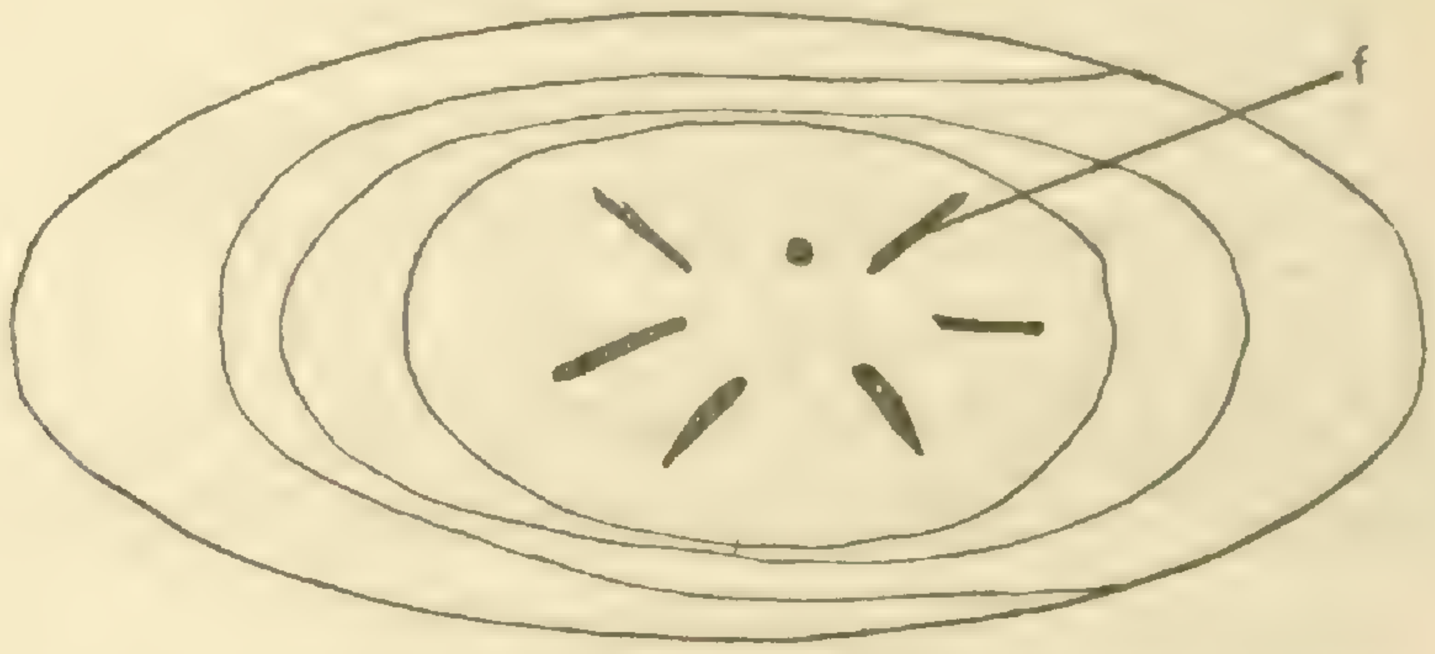
At the level at which the bracts are inserted the median central bundles of the peduncle (text-figs. 7 & 10, *a*, *a*) each send out a large branch (text-figs. 7 & 10, *c*) horizontally in the median plane, which traverses the bract as the large adaxial median bundle. From approximately the same point on the median central bundles, branches are given off which ascend to the margins of the bracts. The main bundles of the bracts, like those of the leaf, thus come from the central vascular system.

As the horizontal branches (*c*) go off the two ascending median bundles of the peduncle bend towards each other and, forming an arch, fuse. As they bend the central lacunar tissue disappears and is replaced by parenchyma and tannin-cells (text-fig. 7, *p*).

Halfway between the bend and the fusion two large branches (*d*) on each side are emitted in the median plane and run outwards and upwards, branch repeatedly, and anastomose and form part of the ring of peripheral bundles of the ovary.

Immediately after the median bundles fuse the fusion-bundle divides into from six to

Fig. 11.



eight branches (text-figs. 7 & 11, *f*), which bend obliquely out to the midribs of the carpels. Branches of these, as they bend, help to form the peripheral ring of bundles of the ovary.

The vascular structures of the male and female inflorescences show a remarkable similarity in plan; the fate, the subsequent division, and the branching of the median bundles are identical, except that the end of the male peduncle seems to be pushed up to form a tongue, so that the horizontal branches bend down obliquely.

Flower (text-figs. 12 & 13).—The perianth-leaves are in two dissimilar whorls of three petals (*p*) and three sepals (*s*). They both consist of an epidermis and parenchyma-cells from three to four layers thick. The petals have denser contents than the sepals and are very much crinkled, as they fold between the six to eight pairs of stigmas (text-fig. 12, *st*). There are very few tannin-cells.

The inferior ovary has six to eight forked placentæ, which project nearly to the centre of the ovarial cavity (text-fig. 13, *pl*). In the centre is a small column (*c*) with a

Fig. 12.

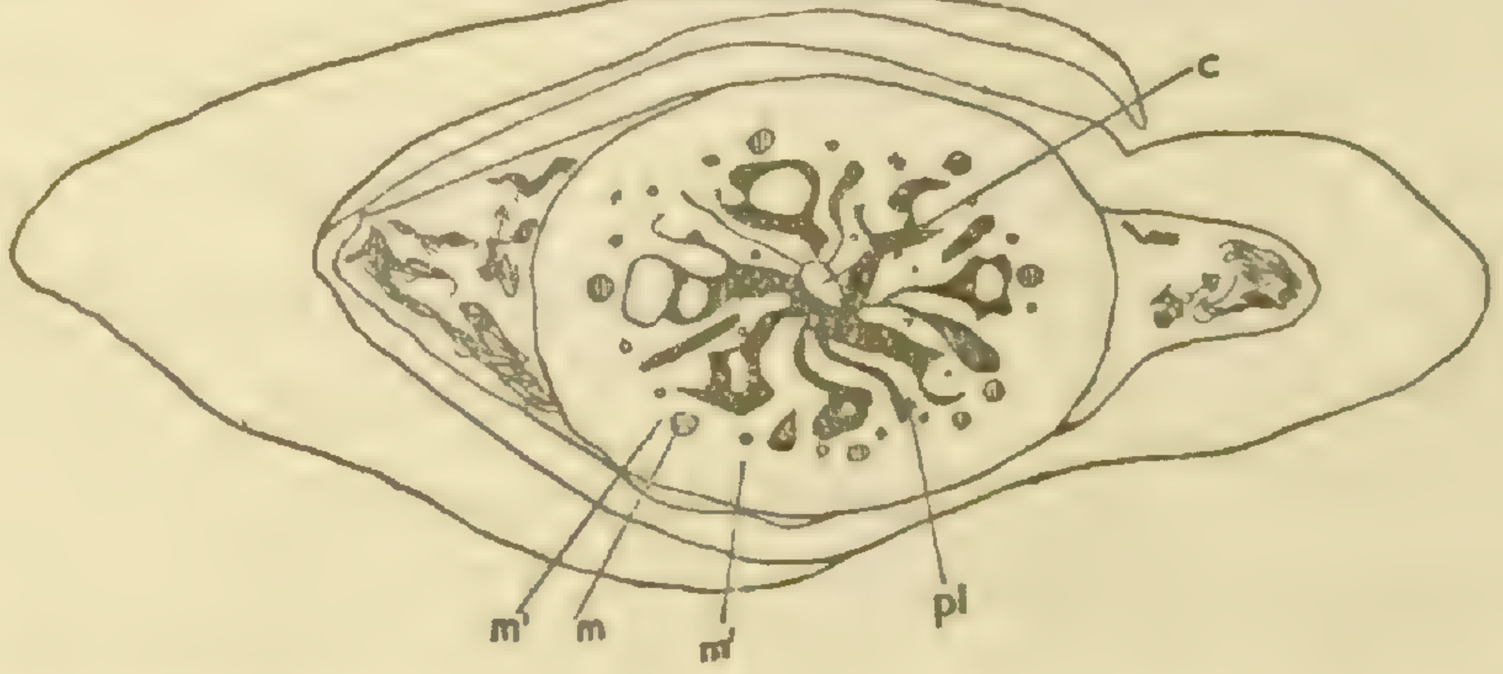


Fig. 13.

small vascular bundle which terminates about halfway up. The vascular structure of the carpels is similar to that of the leaf, as there is a large midrib bundle (text-fig. 13, *m*) in the middle of each carpel and a marginal bundle (*m'*, *m'*) on either side. The projecting

placentæ are like the projecting marginal flaps at the base of the leaves. They each have a small bundle midway between the ovary-wall corner and the inner margin. There is a ring of peripheral bundles (not shown in the figure) round the ovary edge, which anastomose frequently and whose course is difficult to trace. As the top of the ovary is reached it becomes nine-sided in transverse section and the peripheral bundles run in the ridges and pass into the sepals and petals, where they soon die out. They seem to consist only of a few phloem-constituents. The ovarial cavity is filled with mucilage secreted by the innermost cell-layer, which is very rich in starch-grains. Contrary to Svedelius's statement that the mucilage does not extend into the clefts between the projecting placentæ and is not secreted by the cell-layers there, it can be seen extending halfway down these clefts, and the outermost cell-layer is rich in starch and resembles the secreting-cells of the rest of the ovary.

The mucilage is not entirely pectic in nature, as stated by Svedelius, as it stains with Congo red slightly, but can be seen to be largely pectic on staining with Ruthenium red or methylene-blue.

Fruit.—The bracts remain the same size, but the ovary within increases enormously as the fruit develops. Engler states that it is the size of a walnut, but some specimens measured were much larger, being 7 cms. by 4 cms.

Broad longitudinal bands of papillæ are situated on the midribs of the carpels, the number of rows in each band varying according to the space available.

The placentæ increase enormously in size and consequently become lacunar, presenting a very leaf-like appearance. Often they are much distorted, owing to the growth of the seeds, about four of which show in section.

The Seed.—The funicle which leaves a dark circular scar is attached to the middle of the base of the conical seed. There are two easily detachable integuments which form a thick spongy cap over the apex, and there is no endosperm or perisperm.

The embryo is conical in shape, the cotyledon forming the apical part of the cone and the massive hypocotyl the base. The primary root is quite undeveloped. In a groove which extends from the apex to the base of the cotyledon and penetrates nearly to its axis lies the plumule (Pl. 36. fig. 20, *a*). It consists of a well-developed shoot with 4–5 leaves showing median and marginal bundles; these bend in towards one another, and fusing, start the cylinder of the stem. There are also two young adventitious roots arising in the cortex of the stem (Pl. 36. fig. 22, *r*).

There is one cotyledonary bundle (Pl. 36. fig. 21, K) which passes down the centre of the cotyledon, receiving at right angles on one side the bundle (K′) from the primary shoot (*s*) and then continuing as the axial cylinder of the hypocotyl to the base of the embryo (*bb*).

The cotyledon contains a store of starch, and there is a very dense cone of starch-containing tissue over the point of attachment of the funicle.

In conclusion, my best thanks are due to Professor Groom, under whose direction this work was carried out, for all his suggestions, advice, and help.

Imperial College of Science and Technology.

December, 1910.

Bibliography.

Ascherson, P. (1867).—In Linnæa, xxxv. pp. 152–208.

Chatin, G. A. (1892).—Anatomie comparée des Végétaux: Plantes aquatiques. Monocotylédones, pp. 15 & 16.

Engler, A., und K. Prantl (1889).—Die natürlichen Pflanzenfamilien, II. Teil, i. Abteilung, pp. 241–247, 254.

Griffiths, W. (1851).—Notulæ ad plantas asiaticas, vol. ii. pp. 175–179.

Magnus, P. (1871).—Sitzungs-Berichte der Gesellschaft naturforschender Freunde zu Berlin, p. 87.

Richard, L. C. (1812).—Mémoires de la classe des Sciences Mathématiques et Physiques de l'Institut Impérial de France; Année 1811, seconde partie, p. 1.

Rumphius, G. E. (1750).—Herbarium amboinense, vol. vi. p. 191, tab. 75. fig. 2.

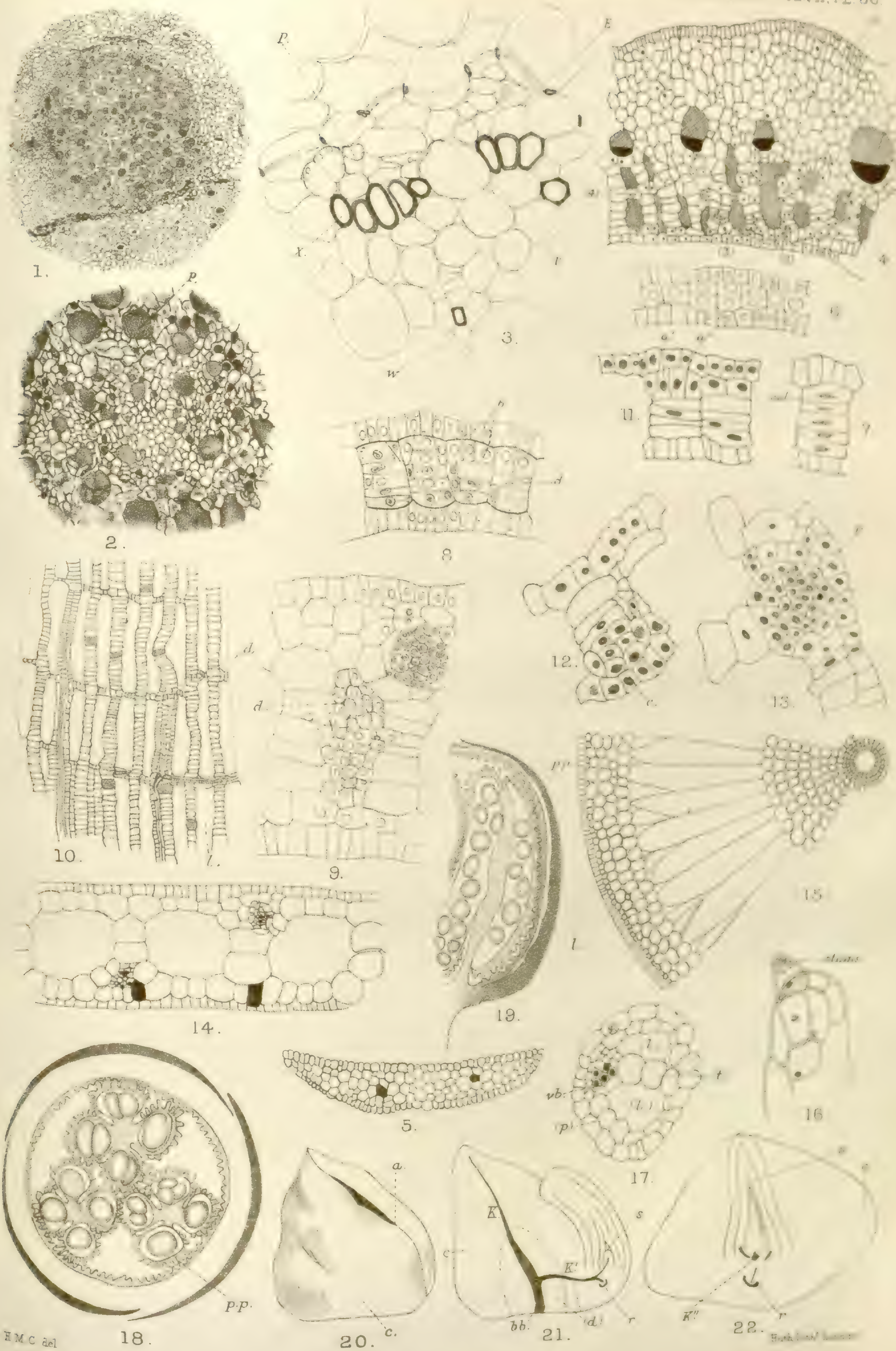
Sauvageau, C. (1890).—In Journal de Botanique, vol. iv. pp. 269–275.

Svedelius, N. (1904).—In Annals of the Royal Botanic Gardens of Peradeniya, pp. 261–297.

Zollinger, H. (1854).—Systematischen Verzeichniss der im indischen Archipel in den Jahren 1842–1848 gesammelten . . . Pflanzen, i. p. 69.

EXPLANATION OF PLATE 36.

Fig. 1. Transverse section of the rhizome (photograph). 13.
2. " " part of the stele, showing tannin-cells. 26. *p*, pigment-cell.
3. " " the stele of the rhizome (cleared with Eau de Javelle). 295. *p*, phloem; E, endodermis; *x*, xylem; *t*, tannin-cell.
4. " " leaf near the base showing obliteration of air-chambers. 155. *b*, bast-fibres; (1) (2) (3) (4), obliteration of air-chambers.
5. " " an intravaginal scale. 236.
6. " " a young leaf. 590.
7. " " " " *col*, column of five cells.
8. " " " " *d*, diaphragm-cell; *b*, developing bundle-cells.
9. " " " showing diaphragms. 590. *d*, diaphragm.
10. Tangential section of an old leaf, showing air-chambers. 94. *d*, diaphragm; *l*, lacuna.
11. Transverse section of a young leaf-bundle. 590. *a*, *a''*, cells of developing bundle.
12. " " " " " *c*, one of the eight cells which form the bundle.
13. " " " " " *p*, primordia of the bundle.
14. " " an old leaf, section taken midway between the base and apex. 64.
15. " " the root.
16. Longitudinal section of a mucilage-papilla. 196.
17. Transverse section of the male pedicel. 472. *l*, lacuna; *p*, parenchyma; *vb*, bundle; *t*, trabecula.
18. Diagram of a transverse section of a male flower. 96. *pp*, papillæ.
19. " " longitudinal section of a male flower. 64. *pp*, papillæ; *l*, loculus.
20. Seed with the testa removed. 2. *a*, groove; *c*, cotyledon.
21. Radial longitudinal section of the seed. 3. *c*, cotyledon; *s*, plumule: *bb*, point of attachment of the funicle; *r*, root; K K', vascular bundles; *d*, dense cone of starch-containing cells.
22. Tangential section of the seed. 3. *c*, cotyledon; *s*, plumule; *r*, root; K'', vascular bundle.



H.M.C. del

ANATOMY OF ENHALUS.

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s.* to the public, and 6*s.* to Fellows; to Vols. 26–30, 4*s.* to the public, and 3*s.* to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

Second Series.—Botany.

Volume.		When Published.	Price to the Public. £ s. d.	Price to Fellows. £ s. d.
I.	Parts I.–IX. (complete).	1875–80.	8 1 0	6 1 0
II.	Part I.	1881.	0 12 0	0 9 0
	Part II.	1882.	0 5 0	0 3 9
	Part III.	1883.	0 10 0	0 7 6
	Part IV.	1883.	0 3 0	0 2 3
	Part V.	1883.	0 3 0	0 2 3
	Part VI.	1884.	0 13 6	0 10 0
	Part VII.	1884.	0 9 6	0 7 0
	Part VIII.	1884.	0 10 0	0 7 6
	Part IX.	1886.	0 7 0	0 5 0
	Part X.	1887.	0 3 4	0 2 6
	Part XI.	1886.	0 6 0	0 4 6
	Part XII.	1886.	0 8 0	0 6 0
	Part XIII.	1887.	1 7 0	1 0 0
	Part XIV.	1887.	0 7 0	0 5 0
	Part XV.	1887.	0 10 0	0 7 6
	Part XVI.	1888.	0 2 6	0 2 0
III.	Part I.	1888.	3 12 0	2 14 0
	Part II.	1891.	0 5 0	0 3 9
	Part III.	1891.	0 7 0	0 5 0
	Part IV.	1891.	0 6 0	0 4 6
	Part V.	1891.	0 6 0	0 4 6
	Part VI.	1891.	0 3 6	0 2 8
	Part VII.	1892.	0 6 0	0 4 6
	Part VIII.	1893.	0 6 0	0 4 6
	Part IX.	1893	1 8 0	1 1 0
	Part X.	1894.	0 10 0	0 7 6
	Part XI.	1894.	0 3 4	0 2 6
IV.	Part I.	1894.	1 0 0	0 15 0
	Part II.	1894.	2 0 0	1 10 0
	Part III.	1895.	2 10 0	1 17 0
	Part IV.	1895.	0 3 4	0 2 6
V.	Part I.	1895.	0 9 0	0 6 9
	Part II.	1895.	0 12 0	0 9 0
	Part III.	1896.	0 6 0	0 4 6
	Part IV.	1896.	1 0 0	0 15 0
	Part V.	1896.	0 14 0	0 10 6

Second Series.—Botany (*continued*).

Volume.		When Published.	Price to the Public. £ s. d.	Price to Fellows. £ s. d.
V.	Part VI.	1896.	0 4 0	0 3 0
	Part VII.	1897.	0 4 0	0 3 0
	Part VIII.	1897.	0 6 0	0 4 6
	Part IX.	1899.	0 12 0	0 9 0
	Part X.	1899.	0 6 0	0 4 6
	Part XI.	1899.	0 7 0	0 5 0
	Part XII.	1899.	0 12 0	0 9 0
	Part XIII.	1900.	0 1 6	0 1 2
	Part XIV.	1900.	0 3 0	0 2 3
	Part XV.	1901.	0 6 0	0 4 6
VI.	Part I.	1901.	1 10 0	1 2 6
	Part II.	1901.	0 6 0	0 4 6
	Part III.	1902.	0 18 0	0 13 6
	Part IV.	1903.	0 8 0	0 6 0
	Part V.	1903.	0 8 0	0 6 0
	Part VI.	1903.	0 12 0	0 9 0
	Part VII.	1904.	0 12 0	0 9 0
	Part VIII.	1904.	0 12 0	0 9 0
	Part IX.	1904.	0 7 0	0 5 3
	Part X.	1904.	0 14 0	0 10 6
	Part XI.	1905.	0 4 0	0 3 0
VII.	Part I.	1904.	0 5 0	0 3 9
	Part II.	1905.	0 6 0	0 4 6
	Part III.	1906.	0 3 0	0 2 3
	Part IV.	1906.	0 7 0	0 5 3
	Part V.	1907.	0 10 0	0 7 6
	Part VI.	1907.	0 4 0	0 3 0
	Part VII.	1907.	0 6 0	0 4 6
	Part VIII.	1908.	0 5 0	0 3 9
	Part IX.	1908.	0 2 6	0 2 0
	Part X.	1908.	0 7 0	0 5 3
	Part XI.	1909.	0 4 0	0 3 0
	Part XII.	1909.	0 12 0	0 9 0
	Part XIII.	1909.	0 5 0	0 3 9
	Part XIV.	1909.	0 6 0	0 4 6
	Part XV.	1910.	0 6 0	0 4 6
	Part XVI.	1912.	0 3 0	0 2 3

2nd Ser. BOTANY.]

[VOL. VII. PART 17.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

ON BOTRYCHIOXYLON PARADOXUM, SP. NOV., A PALÆOZOIC FERN WITH SECONDARY WOOD.

BY

DUKINFIELD HENRY SCOTT, F.R.S., P.L.S.

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

July 1912.

XVII. *On* Botrychioxylon paradoxum, *sp. nov., a Palæozoic Fern with Secondary Wood.*

By D. H. Scott, *F.R.S., P.L.S.*

(Plates 37–41.)

Read 18th April, 1912.

In 1906, in a communication to the Royal Microscopical Society, I shortly described a new genus, named *Botrychioxylon*, from the Lower Coal-measures of Lancashire, remarkable for possessing radially seriated wood, apparently of a secondary character (Scott, '06[1]). Later in the same year I gave a somewhat fuller account of *Botrychioxylon* in an article in the 'Progressus Rei Botanicæ' (Scott, '06[2]). I may quote this account as a brief introduction to the more detailed description of the plant to which the present paper is devoted:—

"The branched rhizome is traversed by an almost cylindrical stele, the wood of which consists of two parts: the centre is occupied, as in *Zygopteris*, by small tracheides scattered among parenchyma, while the main part of the wood forms a broad surrounding zone of much larger elements. The point of interest is that the outer zone has its elements radially arranged, constituting to all appearances a secondary tissue, just as is the case in *Botrychium* among recent Ferns. Otherwise the fossil bears considerable resemblance to *Zygopteris corrugata*: anatomically *Botrychioxylon* shows a relation to *Zygopteris*, like that of *Botrychium* to *Ophioglossum*, and it is on this ground that the name of the fossil genus has been selected." I further pointed out in both communications that this was the only case as yet noticed among the Botryopterideæ * in which there was evidence of secondary growth. In the second edition of my 'Studies in Fossil Botany' I again referred to the plant, suggesting that some real affinity with the Ophioglossaceæ might be indicated (Scott, '08, pp. 318, 344). At that time I thought that *Botrychioxylon* might eventually have to be included under *Zygopteris*, but that genus has since been completely broken up by the researches of Dr. P. Bertrand. The relation of our plant to *Ankyropteris corrugata* (formerly *Zygopteris corrugata*) (Williamson, '77) will be discussed farther on in the paper (p. 384).

The only other reference to *Botrychioxylon* that need be mentioned here is one by Professor Bower (Bower, '11[2], p. 546), whose short account of the structure is based on an inspection of the preparations in my collection.

General Structure.

The specimen on which the new genus and species are based was found by Mr. James Lomax in a coal-ball from Moorside, Oldham, the horizon being that of the Upper Foot Mine. The preservation is fairly good, though there is a want of sharpness in certain

* Used in the wide sense, as by Renault, to include the Zygopterideæ.

details, such as the sculpture of the tracheides. The first sections were sent me on January 10th, 1902. The long delay in publishing a full description of the specimen, which Mr. Lomax detected as a "new stem," is due, among other causes, to certain difficulties of interpretation, which even now are not completely surmounted.

I have eight sections in all (Nos. 2459–2466 in my collection), of which six are transverse and two are longitudinal. Three of the transverse sections (2459–2461) are from the lower part of the specimen; then come the longitudinal sections (2462 and 2463), passing through the bifurcation of the stem; the remaining transverse sections (2464–2466) are from the upper part of the specimen and are cut through the more vertical of the two branches.

The two branches into which the stem divides are approximately equal in size (Pl. 39. fig. 10); the fact that the branching, so far as we are able to judge, was by dichotomy is an important one and a striking point of agreement with the stems of *Ankyropteris corrugata* (Pl. 40. fig. 19), *Diplolabis Römeri*, and *Metaclepsydropsis duplex*.

The stem bears appendages of three kinds: leaves, aphlebiæ, and adventitious roots. No petiole is shown in actual connection with the axis, but there is no doubt, as will be further explained below, that the petiole seen in the upper transverse sections belongs to the plant (Pl. 37. fig. 4). Aphlebiæ, comparable to those of other Zygopterideæ, and adventitious roots are seen in continuity with the stem at various places.

The stem does not diminish in thickness, within the limits of the specimen. In the lowest section the diameter is about 9 mm.; in the section next above the dichotomy the one branch shown measures about 1 cm.; in the following sections the stem is incomplete, but appears to keep about the same size. On the other hand, the stele is much smaller above the dichotomy. In the lowest section it measures 3·2×2·7 mm. In that next below the dichotomy (2461) the dimensions are 3×4·4 mm., the increase in one direction being partly due to obliquity of section; above the dichotomy (section 2464) the stele of the vertical branch is only 1·7 mm. in diameter, and in the next higher section only about 1 mm., but here the condition is not quite normal. The structure of the stem is simple. The stele, where not affected by the emission of appendages, has an approximately circular transverse section (Pl. 38. fig. 6). Its structure is described in the next part of the paper. Beyond the stele is a very wide cortex of almost uniform structure throughout. In the lower sections (Pl. 37. figs. 1 & 2 and Pl. 38. fig. 5) the inner cells are tangentially compressed, owing probably to secondary growth of the stele, but in the upper part, where this growth is less in amount, there is scarcely any differentiation (Pl. 38. fig. 6). The absence of mechanical tissues suggests that the stem was a rhizome. On the outside is a definite layer of periderm, several cells in thickness (Pl. 37. fig. 3).

Structure of the Stele.

The structure of the stele is shown, in transverse section, in the photographs (Pl. 37. figs. 1 & 2, Pl. 38. figs. 5 & 7, and Pl. 39. fig. 8). The main features—the central "mixed pith," the broad zone of radially seriated wood, and the somewhat narrow phloem-region on the outside—are evident at the first glance. In the lower sections (Pl. 37. figs. 1 & 2 and Pl. 38. fig. 5) the central tissue has an elongated form and appears compressed,

while the surrounding xylem-zone is of great thickness, with as many as 20 elements in a radial row. In the section above the dichotomy (Pl. 38. fig. 7), the best for details, the "mixed pith" is nearly isodiametric (0·4–0·5 mm. in diameter) and the radially arranged wood less extensive, reaching about 10 elements in thickness. It is probable that the flattened, irregular shape of the central tissue in the lower sections is in part due to pressure set up by continued secondary growth, as happens in the case of the pith of *Aristolochia*, among living plants (De Bary, '84, p. 533). The inner margin of the zone of wood shows five or six slightly convex protrusions towards the mixed pith, which extends outwards to a varying extent between them, so that its outline is somewhat fluted or crenulated (see Pl. 37. fig. 1, Pl. 38. fig. 7, and Pl. 41. fig. 20). At certain points the angles of the central tissue are prolonged outwards for a considerable distance into the zone of wood, sometimes extending through its whole thickness, so as to form apparent rays. It appears, however, that these ray-like prolongations contain tracheides and are connected with the emission of strands to the various appendages of the stem. It is doubtful whether true medullary rays are present; if so, they must be very few in number. Transverse sections afford no decisive proof of their existence; in the radial section (Pl. 39. fig. 10) there appears to be a true ray, with square cells, at *m.r.*, but one cannot be certain that the structure may not have been connected with some outgoing strand. Tangential sections are needed to settle the question.

The radial seriation of the tracheides is quite regular, so that the tissue presents all the appearance of a zone of secondary wood. In the best transverse section the cambial cells and young xylem-elements are very clear, especially at one point (Pl. 38. fig. 7. *cb.*). There thus seems to be no doubt that the radially seriated zone really represents a product of secondary growth carried on by means of a cambium-layer. This is confirmed by the diminution in thickness of the zone of wood in the upper part of the stem, while the primary central tissue maintains an almost constant size throughout. Little, if any, secondary phloem appears to have been added by the cambium.

The uppermost section showing the stele has a peculiar structure, no doubt partly pathological (Pl. 39. fig. 8). There is here a considerable formation of wound periderm in the cortex, and on this side the stele is incomplete, for there is no secondary wood, though on the other side it is well developed, reaching a thickness of about 8 elements. It may be pointed out that the effect of the injury has apparently been to inhibit the formation of the secondary tissues; their presence is evidently the normal condition.

In all the sections the nature of the "mixed path" is clear; it consists of small tracheides intermingled with parenchyma. The structure is best shown in the upper transverse sections (Pl. 38. fig. 7, Pl. 39. fig. 8, Pl. 41. fig. 20). The internal tracheides range, as a rule, from about 30–50 μ in diameter, but the smallest elements measure only 12–24 μ; the secondary tracheides range about 40–80 μ in diameter, the larger sizes predominating. Of the internal tracheides, those towards the middle of the mixed pith are usually the larger. It is not easy to locate the protoxylem, but in some places groups of very small tracheides which are probably of this nature lie on the outside of the primary wood near the beginning of the secondary zone (see Pl. 39. fig. 8, Pl. 41. fig. 20). This is well seen in the uppermost section (Pl. 39. fig. 8), where one such group (*px.*) is

almost wedged in between the strands of secondary xylem. At any rate, such indications of protoxylem as we find point to a centripetal development of the internal xylem.

The longitudinal section passing through the "mixed pith" shows that the larger internal tracheides are long scalariform elements. The part figured (Pl. 41. fig. 22) shows three of the smaller tracheides, about 20 μ in diameter; some of them appear to be spirally thickened.

The large tracheides of the secondary wood have scalariform markings, the bars being often short, so that there are two or three series on the same wall (Pl. 41. fig. 21). There are no tangential sections, but, judging from oblique parts of the transverse sections, it appears that the sculpturing was present on the tangential as well as on the radial walls. The cells of the ground-tissue accompanying the internal xylem are shown in longitudinal section to have been of moderate length, with square ends (Pl. 41. fig. 22). Some of them have dense brown contents. The small-celled phloem is fairly shown in places in the best transverse section (Pl. 38. fig. 7), and in the longitudinal section the elements are seen to be elongated. No definite pericycle or endodermis has been identified.

It will be noticed that the structure of the stele agrees closely with that of such a member of the Zygopterideæ as *Ankyropteris corrugata*, with the one important difference that the peripheral zone of xylem, which is part of the primary structure in the *Ankyropteris*, is here a secondary tissue. It is true that in *A. corrugata* formation of secondary xylem is not unknown. In a small dichotomizing stem in my collection there is very distinct secondary wood in one of the two steles resulting from the bifurcation (Pl. 40. fig. 19, x^2). It is, however, only a local formation, superadded to the normal woody zone, and it is only represented to a small extent in the sister stele. In *Botrychioxylon* the main part of the wood is secondary, only thinning in the upper part of the stem. In fact, so far as the peripheral xylem-zone is concerned, the condition is the same as in *Botrychium*, where the primary wood of related Ferns is mostly or even wholly replaced by radially seriated tissue with cambial growth. In *Botrychium*, of course, there is, as a rule, no internal xylem, so that in some cases practically nothing primary is left. Recent work, however, has shown that internal tracheides occur normally in the first-formed part of the stem as well as occasionally in advanced specimens and abnormally as a traumatic effect (*B. ternatum*) (Bower, '11[2]). The analogy with *Botrychioxylon*, as Prof. Bower has pointed out, thus becomes extremely close, even closer than I realized when the comparison first occurred to me. Internal tracheides have also been observed in the other genera of Ophioglossaceæ, both in the stem of the sporeling and in small stocks. In these genera the woody zone is primary. Thus there is a complete analogy in these respects between the Zygopterideæ (including *Botrychioxylon*) and the modern Ophioglossaceæ, with the distinction that in the former the internal tracheides are constantly present, while in the latter they have come to be only an occasional feature of the structure.

The Leaf-Trace.

The stele in the transverse section shown in Pl. 37. fig. 2 is evidently preparing to give off a large lateral strand to some appendage. The protrusion of the wood (*l.t.*) is 1·5 mm. wide at the base; a strand of nearly horizontal tracheides passes out into it

from the internal xylem, spreading out laterally in a somewhat Y-shaped form. All the outer part of the protrusion is composed of the secondary wood, here cut rather obliquely. The whole bears a striking resemblance to an early stage in the emission of a leaf-trace in *Ankyropteris corrugata*, as shown, for example, by Dr. P. Bertrand ('09, pl. xii. fig. 87). The difference is simply that which distinguishes the steles as a whole—the outer wood of the appendage is primary in *Ankyropteris corrugata*, secondary in *Botrychioxylon* *. Internal xylem is, of course, present in the *Ankyropteris* just as in our plant, though unfortunately not mentioned in Dr. Bertrand's description ('09, p. 110).

We can scarcely doubt that the protrusion of the xylem shown in Pl. 37. fig. 2 is of the same nature as the similar structure in *A. corrugata*, namely, a leaf-trace preparing to detach itself from the stele. From the analogy of the plant referred to we should expect the leaf-trace, when free, to have two immersed groups of protoxylem near its two extremities, possibly with a third transitory group in the median position (Bertrand, '09, pl. xii. fig. 88). In *A. corrugata* all the three groups are connected with the internal xylem of the stele, just as is the case in *A. Grayi* (Scott, '12, p. 48).

The section next above the one just mentioned shows a large strand in the cortex precisely corresponding in position to the stelar protrusion in the lower section (see Pl. 38. fig. 5). It is here separated from the stele by a tract of cortical tissue, and happens to be further pushed out by the intrusion of a Stigmarian rootlet; the true relations of position are, however, clear. There can be no doubt that the strand seen in this section is the same which was preparing to leave the stele in the section next below (compare Pl. 37. fig. 2 and Pl. 38. fig. 5). The structure of the strand is, however, in a high degree peculiar and different from what we should have expected (Pl. 39. fig. 9). The wood of the strand measures about $860 \times 620\,\mu$, the longer axis being tangential; beyond the wood is a zone of phloem, then a layer or two of parenchyma, and a somewhat interrupted dark-coloured band of cells, which may possibly represent an endodermis. Nearly the whole of the wood is radially seriated and of a secondary character; the preservation is good, and at some points the tabular cambium-cells are quite recognizable. The secondary wood reaches a thickness of from 5 to 7 elements, the greater thickness being on the abaxial side. Between the two arcs of secondary wood is a narrow band of somewhat compressed elements, no doubt representing the primary xylem. This band is concave towards the exterior of the stem. At each end of the primary band is a group of small elements (best shown on the right) which may probably be the protoxylem.

What view are we to take as to the nature of this strand? There are three possibilities. it might be the stele of a root, the stele of a branch, or a leaf-trace bundle.

The diarch structure is favourable to the first interpretation, for we know that the plant had diarch roots (Pl. 40. figs. 14 & 16). The secondary tissues are also consistent with this view, for some of the undoubted roots possess secondary wood (Pl. 40. fig. 16). On the other hand, the dimensions are a good deal too large for a root, if we may judge from the other examples present in the specimen. The largest root-stele

* As a matter of fact, some radially seriated wood is shown (at *rad.*) in Dr. Bertrand's photograph, but this he connects with the departure of a root-strand.

observed has a diameter of about 0·4 mm.—roughly half that of the strand under discussion. It may be added that there is no clear sign of any cortex belonging to the strand, such as should be present if the organ were an endogenous one, like an adventitious root. Further, the marked curvature of the primary xylem-plate is not to be expected in a root. None of these arguments are, however, in themselves conclusive.

So far as structure is concerned, the strand in question might quite well belong to a branch, comparable to the axillary branches of *Ankyropteris scandens* or *Grayi*. For example, the axillary stele from the latter species, figured in a recent paper (Scott, '12, pl. ii. phot. 10), agrees quite well, allowing for the difference between primary and secondary wood. The branch interpretation is, however, ruled out of court by the fact that the branching in *Botrychioxylon* was dichotomous (Pl. 39. fig. 10), the bifurcation taking place immediately above the level of the problematic strand. We cannot suppose that two different kinds of branching took place in the same stem within a few millimetres of each other.

There remains the leaf-trace interpretation. This finds support, first, in the mode of departure of the strand from the stele, shown in the section next below that which contains the strand in the cortex. Here, as we have seen, the structure is as nearly as possible the same as that shown at a corresponding stage of the emission of a leaf-trace in *Ankyropteris corrugata*; it may also be compared in this respect with *Metaclepsydropsis duplex* *. Another important argument is derived from the presence of a petiole in the next transverse section above that showing the strand (Pl. 37. fig. 4). The region of bifurcation shown in longitudinal section in Pl. 39. fig. 10 intervenes, but the vertical distance is small, the height of the intermediate piece from which the longitudinal sections were cut being only 3 mm. The petiole is on the same side of the stem as the strand, the oblique branch of the bifurcation having gone off on the opposite side. The petiole is not in continuity with the stem, but there can be no reasonable doubt that it belongs to it; the structure of the tissues is the same, except that the petiole, as we should expect, has a stronger mechanical construction, the middle cortex being differentiated as a somewhat sclerotic zone (Pl. 39. figs. 11 & 12). The appendage borne by the petiole is identical with the large aphlebiæ which occur on the stem and are described below. The petiole contains a singular vascular bundle resembling the *Dineuron* type (see below, p. 379).

There is a strong presumption that the petiole is the organ to which the strand shown in the lower section belongs, and that the strand is therefore a leaf-trace which becomes the petiolar bundle higher up in its course. The curvature of the primary xylem, with concavity outwards, is characteristic of Zygopteridian leaf-traces. Taking all the facts into consideration, I believe that this is the right interpretation, and that the strand in question is a leaf-trace with secondary wood †. On this view it is perfectly comparable to the stele of the stem; in both, only the central part of the xylem retains a primary character; the outer zone has been formed by secondary growth and betrays its cambial origin in the radial seriation of its elements. In both, the considerable secondary

* Gordon, '11[2], pp. 174 & 183, figs. 7–16.

† An apparently similar strand is incompletely shown in the tangential section of the cortex (2463).

development has led to some compression of the primary xylem. There is nothing so very surprising in finding that the substitution of secondary for primary wood has extended from the stele to the lower part of the leaf-trace; analogous cases, though scarcely known among Ferns, are familiar in Cycads and other Gymnosperms, as well as Dicotyledons. A second specimen, probably also referable to *Botrychioxylon*, confirms the view here taken in a rather striking manner, for it shows a leaf-trace in which the replacement of primary by secondary tissues has taken place in a more partial degree (Pl. 40. fig. 18).

The Petiole.

The structure of the petiole is shown in two sections, that already referred to and the next above it. A third section (2466) is of little importance, as the vascular bundle is missing. In the lowest section the dimensions of the petiole are about 5·3 × 3·5 mm.; the outline is irregular, owing partly to the presence of a large aphlebia (Pl. 37. fig. 4). The preservation is not perfect throughout, but the bundle is fairly well shown (Pl. 39. fig. 11), as is also the case in the following section (Pl. 39. fig. 12), in which the petiole is less complete. The measurements of the bundle are about 1 mm. × 0·5 mm. There is a resemblance at first sight to Renault's figure of his *Dineuron pteroides* (Renault, '96, fig. 19, p. 23), the similarity being accentuated by the fact that the middle part of the xylem-plate is thin-walled (immature) in both. This, however, is clearly an accidental agreement, and a closer examination reveals important differences in the essential characters.

In the lower section of the two (2464) the general outline of the bundle is well defined and is somewhat hourglass-shaped (Pl. 41. fig. 23). The xylem is only slightly dilated at the two ends, so that antennæ can scarcely be said to be developed. The median band ("apolar" of Dr. P. Bertrand) is straight and consists of large elements; the walls of the middle tracheides are still incompletely thickened. At the ends, where the xylem slightly spreads out, the elements are smaller; some of these also seem to be immature. There is a slight sinus at each end; the cells in the depressions are a little disorganized, there is no trace of any external xylem (filament) closing in the sinus, all the adjacent tissue being thin-walled; neither are the cells small enough to be reasonably regarded as representing a "filament" in an immature stage (Pl. 41. fig. 23).

The upper section (2465) is in some respects more characteristic. Here there is a quite definite cavity at each end of the xylem (Pl. 39. fig. 13 and Pl. 41. fig. 24). One may fairly suppose that these gaps mark the position of the protoxylem, though I have not been able to detect its elements. No doubt the gaps are of the nature of peripheral loops or sinuses. I have endeavoured to ascertain which they are. At both ends the tissue bordering the gap externally is badly preserved, with broken cell-walls; some of the broken walls are rather thick, but the appearance of thickening may only be the effect of decay: the tissue resembles ill-preserved phloem rather than xylem. Thus in neither section is there any evidence of the presence of a "filament" or external border of xylem, forming a peripheral loop; on the evidence available it appears that the sinuses were open, though the preservation is not good enough to remove all possibility

of doubt. Open sinuses (closed only at the emission of a lateral strand) are characteristic of *Dineuron*; but we cannot refer our petiole to that genus, for in the upper of the two sections (2465) there are fairly well-marked antennæ, the terminal regions of the xylem being much broader than the median band (Pl. 41. fig. 24).

The phloem is preserved, but not well defined. It is best shown in the lower section (see Pl. 41. fig. 23); in the parts bordering on the median band it is a large-celled tissue. A definite layer bounding the whole bundle in this section may possibly be the endodermis, and the tissue immediately within it the pericycle; in the upper section these regions are very ill defined (Pl. 41. fig. 24).

It would be a great help in determining the relationships of the petiole if the secondary rachis-bundles were present; there are some obscure indications in the cortex of the petiole which may be of this nature, but the preservation is too bad for anything to be made of them.

As the evidence is against the presence of a "filament," the sinuses thus being open and not forming peripheral loops, we cannot place our plant in the genus *Ankyropteris*: the same consideration excludes the genera *Clepsydropsis* and *Asterochlæna*. We have seen that the form of the petiolar bundle forbids a reference to *Dineuron*; there are no grounds for a comparison with the restricted genus *Zygopteris**.

The only genera of Zygopterideæ which can be taken into consideration are *Etapteris*, *Diplolabis*, and *Metaclepsydropsis*. We know nothing of the stem of *Etapteris* or of the basal region of the petiole. There is a slight sinus at each end of the xylem, between the protoxylem groups (P. Bertrand, '09, fig. 20, p. 142, and '11, fig. 3, p. 26), and it is conceivable that at the base of the petiole, where the whole structure would no doubt be more condensed, the bundle might resemble that in *Botrychioxylon*. This, however, is merely conjectural. A petiole of *Etapteris Scottii* is associated with the *Botrychioxylon*, but the petiole and rachis of an *Ankyropteris* are also present, and no conclusion can be drawn. Both in *Diplolabis* and *Metaclepsydropsis* the sinuses of the petiolar xylem are open. Dr. Gordon in his memoir on *Diplolabis Römeri* (Gordon, '11^1) has demonstrated the remarkable changes which the leaf-trace passes through in its course. At a low level there is some resemblance to the *Botrychioxylon* bundle (Gordon, '11, pl. 2. fig. 25), though not an exact one. The analogy is of some interest, though the stem-structure precludes any very close affinity.

As regards *Metaclepsydropsis*, also thoroughly investigated by Dr. Gordon ('11^2), what has been said of *Dineuron* may be repeated, for at low levels the *Metaclepsydropsis* trace has almost exactly *Dineuron* structure (Gordon, '11^2, p. 171, pl. 2. fig. 24, &c.). At no level has the bundle of *Metaclepsydropsis* any prominent antennæ such as we find in the upper section of our petiole (Pl. 39. fig. 13 and Pl. 41. fig. 24). Still, there is a general resemblance, especially in the lower part of the petiole (Gordon, '11^2, pl. 2. figs. 19–22), and taking the stem-structure into account it appears that the two genera are somewhat nearly allied.

On present evidence, the petiolar structure of *Botrychioxylon* does not agree with

* For these genera see P. Bertrand, '09 and '11.

that of any known genus of Zygopterideæ, though the discovery of more complete and better-preserved petioles may throw a new light on the question.

The Aphlebiæ.

Aphlebiæ or "scale-leaves" are borne both on the stem and the petiole. Examples of the former case are shown in Pl. 37. fig. 1 and Pl. 40. fig. 14, and of the latter in Pl. 37. fig. 4. The aphlebiæ are different from those of *Ankyropteris Grayi* (Scott, '12, pl. iv. fig. 7) or of *A. corrugata* (Scott, '08, fig. 117). They are compound, branched structures, and their branches have an almost circular transverse section (Pl. 40. fig. 15), so that it is easy at first sight to confuse them with roots. They can, however, be distinguished with certainty by two characters: the aphlebia has a sclerotic, inner cortex, which does not exist in the root (*cf.* Pl. 40. fig. 16), and the vascular bundle of the aphlebia is very small compared with the stele of the root. The aphlebiæ are inserted on the stem by a broad base (Pl. 40. fig. 14); the sclerotic cortex extends a little way into the thin-walled cortical tissue of the stem or petiole. In the triple aphlebia, shown in Pl. 40. fig. 15, two of the branches are in obvious connection, and there is little doubt that the third is also part of the same organ. As shown at several places, the aphlebiæ often branch at the point where they leave the stem, forking into two or more equal limbs. Thus the aphlebia shown on a large scale in Pl. 40. fig. 14 is one branch of a double appendage, seen as a whole in the general view (Pl. 37. fig. 1), the two main branches running in opposite directions, like the thorns of a *Robinia*.

The small strands, surrounded by a sheath, which are seen in the cortex of the stem (Pl. 38. fig. 6), no doubt supplied the aphlebiæ; they can be traced into connection with the stele. The fact that these strands occur singly and not in pairs or groups indicates that the paired aphlebiæ above described are rightly regarded as branches of one, and not as distinct organs.

The details of the vascular strand are not clearly shown; so far as can be seen the xylem is a solid strand of tracheides.

The remarkable appendages which we name aphlebiæ are characteristic of the family Zygopterideæ, but those of *Botrychioxylon*, which might almost be described as compound spines, are a peculiar and conspicuous feature of our plant.

The Roots.

Adventitious roots are borne on the stem in considerable numbers. In one of the transverse sections (Pl. 37. fig. 2) three horizontal strands are seen passing out through the cortex, and are clearly those of roots. In the largest the xylem is 300 μ in diameter. Free roots are frequently seen outside the stem; a small root (0·4 mm. in diameter) is shown in Pl. 40. fig. 14). This has a small diarch xylem-plate; the inner cortex consists of a large-celled tissue, while the outer zone is more dense; it is a root of

quite the ordinary Botryopteridean * type. Roots, however, also occur in which the diarch xylem-plate is increased by the addition of secondary tissue. Roots with secondary growth are so rare in plants of this affinity that it is essential to find strict proof that the organs in question really belonged to our plant. This I was able to prove in the case of the large root (1·7 mm. in diameter) shown in Pl. 40. fig. 16. In Pl. 37. fig. 4 two large branching outgrowths are seen springing from the stem, one on either side of the petiole. One of these outgrowths ends in a body (*r.*), which can be traced through the next two sections, becomes free, and appears as a manifest root in the section figured (Pl. 40. fig. 16). The xylem-plate is incomplete, but was evidently diarch; two or more layers of secondary xylem-elements have been added on either side of the primary plate; they appear to be interrupted opposite the protoxylem; the outer secondary tracheides are large, suggesting a possible function as a water-reservoir. In the outer part of the cortex the cells show a radial seriation indicating that a periderm had been formed. Periderm in roots is not unknown among Zygopterideæ, it is commonly present in the larger roots of *Ankyropteris corrugata.* I have also found secondary wood well developed at the base of a root of this species †, but such cases are rare. It is interesting to recall that Mr. Boodle found abundant secondary wood at the base of the root in *Botrychium Lunaria*, and also, though only to a small extent, in roots of *Ophioglossum vulgatum* (Boodle, '99, pp. 386–388, pl. 20. figs. 9 & 14).

The branched outgrowths already referred to (Pl. 37. fig. 4) are curious structures: they are closely associated with aphlebiæ, and at first sight suggest some kind of cauline appendage; on closer examination, however, it appears that they are merely branched roots: wherever any structure can be made out it agrees with that of a root; the associated aphlebiæ are never in connection with the outgrowth, and can sometimes be seen to spring from the stem. In all cases the roots arise close to aphlebiæ, which may have served to protect them when young.

The root-steles, so far as observed, arise directly from the stele of the stem, without any evident relation to the leaf-trace.

The Branching of the Stem.

Little need be added to what has already been said (p. 374). Of the two branches into which the stem divides, the vertical one is shown in its full thickness, while the other is incomplete (Pl. 39. fig. 10). The stele of the complete branch is 2 mm. in diameter at the base, 1·8 mm. higher up. Half the thickness of the other branch is shown; the diameter was evidently about the same in both. The branching was thus a dichotomy, using the word in the somewhat loose sense which is inevitable in dealing with fossils. The petiole shown in Pl. 37. fig. 4 and Pl. 39. figs. 11 & 12 was given off on the side opposite the inclined branch, so we might, if it were worth while, speak of the vertical branch as axillary. Obviously, however, there are no means of ascertaining whether there was any constant relation between the branching and the leaf-insertion.

* Using the word in Renault's original comprehensive sense. † Shown in section 2721 in my collection.

Dichotomy of the stem is now known to have occurred quite commonly in the Zygopterideæ. I have myself recorded it in *Ankyropteris corrugata* (Scott, '08, p. 318) (Pl. 40. fig. 19, here). Cases have since been described by Dr. Gordon in *Diplolabis Römeri* and *Metaclepsydropsis duplex* (Gordon, '11[1], p. 720, and '11[2], p. 173). In both plants the branching is described as a true or equal dichotomy, but in *Metaclepsydropsis* a small stele was once observed, just above a petiole-trace departure, which the author thinks may indicate that unequal dichotomy also occurred. This observation suggests the possible co-existence of dichotomy and axillary branching in the same plant, but the evidence is too incomplete to allow of further speculation. At any rate, equal dichotomy occurred in *Botrychioxylon paradoxum* in the only case in which branching of the stem has been observed.

Other Specimens.

Among some sections in my possession, originally belonging to Williamson, but not included in his collection, are three containing a small fern-stem. One of them is labelled in Williamson's handwriting: "Allied to *R[achiopteris] corrugata*," the latter being, of course, the plant now known as *Ankyropteris corrugata*. The specimen was found and cut by Mr. Lomax, and came from Dulesgate. The sections are numbered 204–206 in my collection. There seems to be no doubt that the stem is the same throughout, but in one of the sections (206) the preservation is very much better than in the other two. The best section is shown in Pl. 40. fig. 17, and a portion in Pl. 40. fig. 18. The outer part of the stem is imperfect, but much of the cortex is preserved. There is a circular stele 1·5 mm. in diameter, and at some distance from it is a large leaf-trace, the tangential length of which (1·6 mm.) somewhat exceeds the diameter of the stele. The structure of the stele appears to be essentially the same as in the type specimen of *Botrychioxylon paradoxum*. There is a small "mixed pith," in which the tracheides are more conspicuous than the parenchyma, and the rest of the wood is made up of radially seriated elements, giving the same impression of secondary development as the wood of the type. There is more indication of medullary rays than we usually find in the latter, though the broadest apparent ray is of a different nature, as it seems to contain tracheides and, no doubt, is an extension of the internal xylem, connected with some appendage. The cortex has practically the same uniform structure as in our plant. The inner cells here also are flattened tangentially.

The leaf-trace has a rather peculiar structure (Pl. 40. fig. 18). There are short antennæ at the ends of the xylem; the protoxylem groups presumably lay on the concave outer side of the antennæ; there is no sign of any "filament" forming a peripheral loop, though the thickness of the section renders a negative conclusion somewhat uncertain. The rest of the xylem has an unusually irregular form. The nearly straight median band ("apolar") appears to have been originally narrow, consisting of little more than a single row of large tracheides; to this, other elements have been added very unequally in different parts, some of them, to all appearances, by means of cambium; in fact, we appear to have here a case of a leaf-trace which owes a portion of its xylem-

development to secondary growth, just as in the supposed leaf-trace of the type, though not to the same extent. A diarch root accompanies the stem.

On the whole, I think this specimen may best be provisionally referred to *Botrychioxylon paradoxum*, though the characters available are not enough to strictly establish specific identity.

I have also five sections (Nos. 1164–1168) of a second Dulesgate specimen, which seems to have some relation to our plant. The preservation is poor, and no leaf-trace or petiole is shown. The stele, which varies much in form in the different sections, owing partly to differences of preservation, is from 1–1·5 mm. in diameter; the natural form appears to have been nearly circular. It has a "mixed pith" which runs out into conspicuous prolongations containing tracheides, very similar to the internal "protoxylem rays" of *Ankyropteris Grayi*; they are more developed than in *A. corrugata* or the *Botrychioxylon* type specimen. The elements of the peripheral zone of wood show some degree of radial seriation, though less regular than in *Botrychioxylon* itself. At one point I detected what appeared to be cambium (thin-walled tabular cells) at the outer border of the wood, so that some secondary increase took place. The cortex agrees with that of *Botrychioxylon*, and diarch roots are present.

I do not consider the evidence sufficient to justify a reference of this specimen to *Botrychioxylon paradoxum*, especially as the wood is not so typically secondary as in the type. It may prove to be of interest as a transitional form, but at present its relations are obscure.

AFFINITIES.

When I first examined *Botrychioxylon* I was impressed by its resemblance to the stem of the plant which we now call *Ankyropteris corrugata*. Evidently Williamson had the same idea when he labelled his Dulesgate specimen: "Allied to *Rachiopteris corrugata*." At one time I was inclined to go further, and felt some doubt whether the new stem might not, after all, be a peculiar condition or a special part of *Ankyropteris corrugata* itself. The idea suggested itself that *Botrychioxylon* might be the rhizome, while the typical *A. corrugata* was the aerial stem; but this hypothesis does not account for the facts, for roots are borne freely on both stems. The points of resemblance between our plant and *A. corrugata* are: the "mixed pith" (internal xylem), the mode of emission of the leaf-trace, the dichotomous branching, the presence of secondary wood in the stem (only occasional in *A. corrugata*), the diarch roots, with periderm and occasional secondary thickening of the wood.

The occurrence of secondary wood in *A. corrugata* seemed at first a striking coincidence; I no longer attach much importance to this, for the same thing has now been found to occur elsewhere—for example, in *Metaclepsydropsis duplex*, in which the small branch observed by Dr. Gordon has, as he points out, a *Botrychioxylon* structure (Gordon, '11[2]). Occasional radial seriation of the xylem is met with in other stems of the group. The characteristic point in *Botrychioxylon* is the fact that the secondary wood extends all through the stem, so far as the specimen shows, and completely replaces the primary peripheral xylem-zone. Nothing like this has been

observed elsewhere among Palæozoic Ferns. No doubt, as our knowledge extends, we shall find plenty of transitional cases between this structure and the usual primary arrangement.

It is no longer possible to regard *Botrychioxylon* as a form of *Ankyropteris corrugata*, for, if we have rightly interpreted the structure of the petiolar bundle, there are no peripheral loops, and the plant is therefore not an *Ankyropteris* at all. As we have seen (p. 380), it cannot on petiolar characters be referred to any of the established genera of Zygopterideæ. The branched spine-like aphlebiæ also form a peculiar character.

On the whole of the evidence at present available we have no alternative but to keep up *Botrychioxylon* as a distinct genus; its place as a member of the Zygopterideæ is clearly established. In its stem-structure it is one of the simpler members of the family, the stele maintaining an almost cylindrical form. The "mixed pith" (internal xylem accompanied by parenchyma) indicates an affinity either with *Ankyropteris* or *Metaclepsydropsis*, for *Diplolabis* has no internal parenchyma and the form of the stele excludes any near relation to *Asterochlæna*. Provisionally, I am inclined to regard *Metaclepsydropsis* as the nearest genus. The two genera agree in :—

1. The structure of the internal xylem.
2. The form of the stele.
3. The presence of secondary wood (constant in *Botrychioxylon*, exceptional in *Metaclepsydropsis*).
4. The dichotomous branching.
5. The open sinuses of the petiolar bundle.

Botrychioxylon, then, is a member of the Zygopterideæ, which, while retaining a simple form of stele, has advanced in the direction of substituting secondary for primary xylem, thus allowing of unrestricted wood-development in proportion to the needs of the plant. It appears that wherever there is a differentiation of internal and external xylem the latter tends to assume a secondary character. We see this in Lyginodendreæ, Calamopityeæ, *Mesoxylon*, and Cycadean foliar bundles. Later on, the internal xylem may disappear altogether—we find it in a moribund condition in *Botrychium*.

It is interesting to see in *Botrychioxylon* the same change extending from the stele to the leaf-trace. In the Dulesgate specimen it is evident that a part of the xylem has been secondarily added (see p. 383). In the type specimen nearly the whole wood has a secondary character, assuming that the strand in question is rightly regarded as a leaf-trace, as to which, I think, there can be no real doubt (see p. 378). In the petiole, however, the whole of the bundle is still primary; the influence of the stelar changes does not reach so far as this.

The anatomical evidence for an affinity between Zygopterideæ and Ophioglossaceæ is materially strengthened by our knowledge of *Botrychioxylon*, as has been explained earlier in the paper (p. 376). The correspondence in the stem-structure is very complete, and Renault's original view, based chiefly on sporangial characters (Renault, '78, p. 114), is now amply confirmed. Prof. Bower, who at one time, as is well known, took a very different view of Ophioglossaceous relationships, now believes that "we may look for

their true place in the direction of the Cœnopterideæ"* (Bower, '11[1], p. 296), and emphasizes the anatomical comparison between the recent family and the Zygopterideæ (Bower, '11[2], p. 546). Prof. Campbell, though he claims for the Ophioglossaceæ a more primitive position than most botanists would allow them, admits the possibility of a relation to the Botryopterideæ (Campbell, '11, pp. 3 & 214). I have always recognized this affinity, and need only repeat what I said in 1909, that "of known plants it is the Botryopterideæ which appear to have most in common with the Ophioglossaceæ" (Scott, '09, p. 640).

It is scarcely necessary for me to discuss the bearing of the facts here detailed on the theoretical question of the morphology of the pith. The matter has recently been fully dealt with by Prof. Bower ('11[2] and '11[3]). So far as the Zygopterideæ are concerned, there seems no room for doubt that the parenchyma of the "mixed pith" is of stelar origin; in fact, if we take the whole range of the Botryopterideæ in the wide sense, we can trace the stages of evolution from an undifferentiated xylem-cylinder, first of a specialized internal xylem and then of the "mixed pith" (Gordon, '11[1] and 11[2]; Scott, '12). But in this fossil group we never get beyond a *mixed* pith; no known member of the Zygopterideæ had got rid of its internal tracheides and arrived at a *true* pith. It is therefore only by bringing in other families, namely, the recent Ophioglossaceæ and both recent and fossil Osmundaceæ (Kidston & Gwynne-Vaughan, '10; Gwynne-Vaughan, '11), that the argument for stelar medullation can be completed. The whole position assumes that the various Zygopteridean types of stem-anatomy are derived from a protostele; if we take the opposite theory, as held by Dr. P. Bertrand ('11[1]), that they arose by condensation of a polystelic structure like that of *Cladoxylon*, the question of the origin of the pith assumes a totally different aspect. Personally, I still incline to the former view.

Summary.

1. The stele of *Botrychioxylon paradoxum* has a simple, nearly cylindrical form. There is a "mixed pith" consisting of internal xylem and parenchyma; the outer zone of wood is entirely secondary, diminishing in thickness towards the upper part of the stem.

2. The cortex is of very uniform parenchymatous structure, and is bounded externally by periderm.

3. The branching of the stem is dichotomous.

4. The leaf-trace is given off from the stele in a similar manner to that of *Ankyropteris corrugata*. The xylem of the trace appears, like that of the stele, to be largely of secondary origin.

5. The petiolar bundle only shows primary tissues. It has short antennæ and a long median band ("apolar"). There appear to be no peripheral loops, the sinus at each end of the xylem being open.

6. Aphlebiæ are borne both on the stem and petiole; they are branched, spine-like organs.

* Prof. Seward's name for the Primofilices of Arber, including the Botryopterideæ of Renault.

7. The adventitious roots are diarch and freely branched. They formed a periderm and sometimes secondary wood.

8. The affinities of *Botrychioxylon* appear to be closest with the genus *Metaclepsydropsis*; in the stem of the latter, however, secondary wood is only formed in exeptional cases.

9. *Botrychioxylon* shows close analogies with *Botrychium*, in which also internal xylem sometimes occurs. The affinity of the Zygopterideæ generally with the Ophioglossaceæ is confirmed.

References.

BERTRAND ('09).—P. Bertrand, Études sur la Fronde de Zygoptéridées. Lille, 1909.

BERTRAND ('11[1]).—Structure des Stipes d'*Asterochlæna laxa*, Stenzel. Mém. de la Soc. Géol. du Nord, t. 7. i., 1911.

BERTRAND ('11[2]).—Nouvelles Remarques sur la Fronde des Zygoptéridées. Mém. de la Soc. d'Hist. Nat. d'Autun, t. 25 (Année 1912).

BOODLE ('99).—L. A. Boodle, On some Points in the Anatomy of the Ophioglosseæ. Ann. of Bot. vol. xiii. p. 377, 1899.

BOWER ('11[1]).—F. O. Bower, Notes on the Morphology of *Ophioglossum* (*Cheiroglossa*) *palmatum*. Ann. of Bot. vol. xxv. p. 277, 1911.

BOWER ('11[2]).—On the Primary Xylem and the Origin of Medullation in the Ophioglossaceæ. Ann. of Bot. vol. xxv. p. 537, 1911.

BOWER ('11[3]).—On Medullation in the Pteridophyta. Ann. of Bot. vol. xxv. p. 555, 1911.

CAMPBELL ('11).—D. H. Campbell, The Eusporangiatæ. Carnegie Institution, Washington, 1911.

DE BARY ('84).—A. de Bary, Comparative Anatomy of the Phanerogams and Ferns. English Translation, Oxford, 1884.

GORDON ('11[1]).—W. T. Gordon, On the Structure and Affinities of *Diplolabis Roemeri* (Solms). Trans. Royal Soc. of Edinburgh, vol. xlvii. pt. 4 (No. 24), 1911.

GORDON ('11[2]).—On the Structure and Affinities of *Metaclepsydropsis duplex* (Williamson). Ibid. vol. xlviii. pt. 1 (No. 8), 1911.

GWYNNE-VAUGHAN ('11).—D. T. Gwynne-Vaughan, Remarks on the Anatomy of the Osmundaceæ. Ann. of Bot. vol. xxv. p. 525, 1911.

KIDSTON & GWYNNE-VAUGHAN ('10).—R. Kidston & D. T. Gwynne-Vaughan, On the Fossil Osmundaceæ: Part IV. Trans. Royal Soc. of Edinburgh, vol. xlvii. pt. 3 (No. 17), 1910.

RENAULT ('78).—B. Renault, Végétaux Silicifiés recueillis aux Environs d'Autun et de St. Étienne. Autun, 1878.

RENAULT ('96).—Bassin Houiller et Permien d'Autun et d'Épinac. Flore Fossile, 2me Partie. Paris, 1896.

SCOTT ('06[1]).—D. H. Scott, On the Structure of some Carboniferous Ferns. Journal of the Royal Microscopical Soc. p. 518. August, 1906.

SCOTT ('06[2]).—The Present Position of Palæozoic Botany. Progressus Rei Botanicæ, Band i. p. 181, 1906.

SCOTT ('08 & '09).—Studies in Fossil Botany, 2nd Ed., 1908 & 1909.

SCOTT ('12).—On a Palæozoic Fern, the *Zygopteris Grayi* of Williamson. Ann. of Bot. vol. xxvi. p. 39, 1912.

WILLIAMSON ('77).—W. C. Williamson, On the Organisation of the Fossil Plants of the Coal Measures: Pt. VIII. Phil. Trans. Royal Society, vol. 167, pt. 1, 1877.

EXPLANATION OF THE PLATES.

All figures, except fig. 19, are of *Botrychioxylon paradoxum.* The photographs frequently need to be examined with a lens.

Plate 37.

Photographs by Mr. W. Tams.

Fig. 1. Lowest transverse section of the stem. *aph.*, branching aphlebia, half of which is shown in fig. 14; *aph.*[1], triple aphlebia shown in fig. 15. Several appendages (probably roots and aphlebia-strands) are in connection with the stele. Periderm (fig. 3) is seen on the right. × about 9. Slide 2459.

2. Next section above. Roots are seen passing out through the cortex. The large outgrowth, *l.t.*, from the stele appears to be a leaf-trace. × 7½. Slide 2460.

3. Outer cortex and periderm from the right of fig. 1. × about 40. Slide 2459.

4. Stem and petiole, from the transverse section next above the dichotomy of the stem. *r.*, branching root. × about 3. Slide 2464.

Plate 38.

Fig. 5. Transverse section next above fig. 2. The leaf-trace, *l.t.*, is seen in the cortex, see fig. 9. The outgrowth *r.* from the stele is probably the base of a root. × 7½. Slide 2461. Photograph by Mr. Tams.

6. Transverse section next above the dichotomy, through the vertical branch. The smaller strands (as at *aph.*) in the cortex are those of aphlebiæ; the larger one, *r.*, is a root. × 13. Slide 2464. Photograph by Mr. J. Lomax.

7. Stele from last section enlarged. *cb.*, cambium. A root-strand is passing out from the stele. × 35. Slide 2464. Photograph by Mr. L. A. Boodle, F.L.S.

Plate 39.

Photographs by Mr. W. Tams.

Fig. 8. Stele from the uppermost transverse section, showing primary xylem and incomplete secondary zone. *px.*, probable protoxylem. The large cortical cells below are connected with a wound. × 70. Slide 2465.

9. Leaf-trace shown in fig. 5, showing primary and secondary wood, cambium, and phloem. *px.*, protoxylem. The top of the figure is towards the outside of the stem. × 50. Slide 2461.

10. Longitudinal section through the dichotomy of the stem. *m.r.*, medullary ray. × 16. Slide 2462.

11. Transverse section of the petiole shown in fig. 4, showing the bundle, *v.b.*, and the cortex with a sclerotic zone. × 16. Slide 2464.

12. Next transverse section of the petiole above fig. 11; an aphlebia, *aph.*, is seen on the right. × 16. Slide 2465.

13. Vascular bundle from fig. 12. Observe the sinus at each end of the xylem. Compare fig. 24. × 44. Slide 2465.

Plate 40.

Photographs by Mr. W. Tams.

Fig. 14. Aphlebia from fig. 1, seen in longitudinal section, in connection with the stem. To the left is a small diarch root, *r*. × 40. Slide 2459.

15. Triple aphlebia from fig. 1, seen in transverse section. × 40. Slide 2459.

16. Root in transverse section, the continuation of the root *r*. seen in fig. 4. The diarch xylem-plate, which is somewhat incomplete, has secondary xylem, $x.^2$. Periderm is shown to the left. × 38. Slide 2466.

17. Transverse section of Williamson's Dulesgate specimen, showing the stele with secondary wood and the leaf-trace. × 20. Slide 206.

18. Leaf-trace from fig. 17, showing the short antennæ, *a*., the median primary xylem-band, *x*., and the irregular secondary xylem, $x.^2$. × 48. Slide 206.

19. *Ankyropteris corrugata*. Transverse section of a dichotomous stem, received from Mr. Lomax. The two steles are shown. That on the left has a band of secondary wood, $x.^2$, chiefly on the left-hand side. A leaf-trace, *l.t.*, is also seen. × about 8. Slide 2715.

Plate 41.

Figs. 20 & 23 from drawings by Miss G. C. Harrison.
Figs. 21, 22, & 24 from drawings by Mr. G. T. Gwilliam.

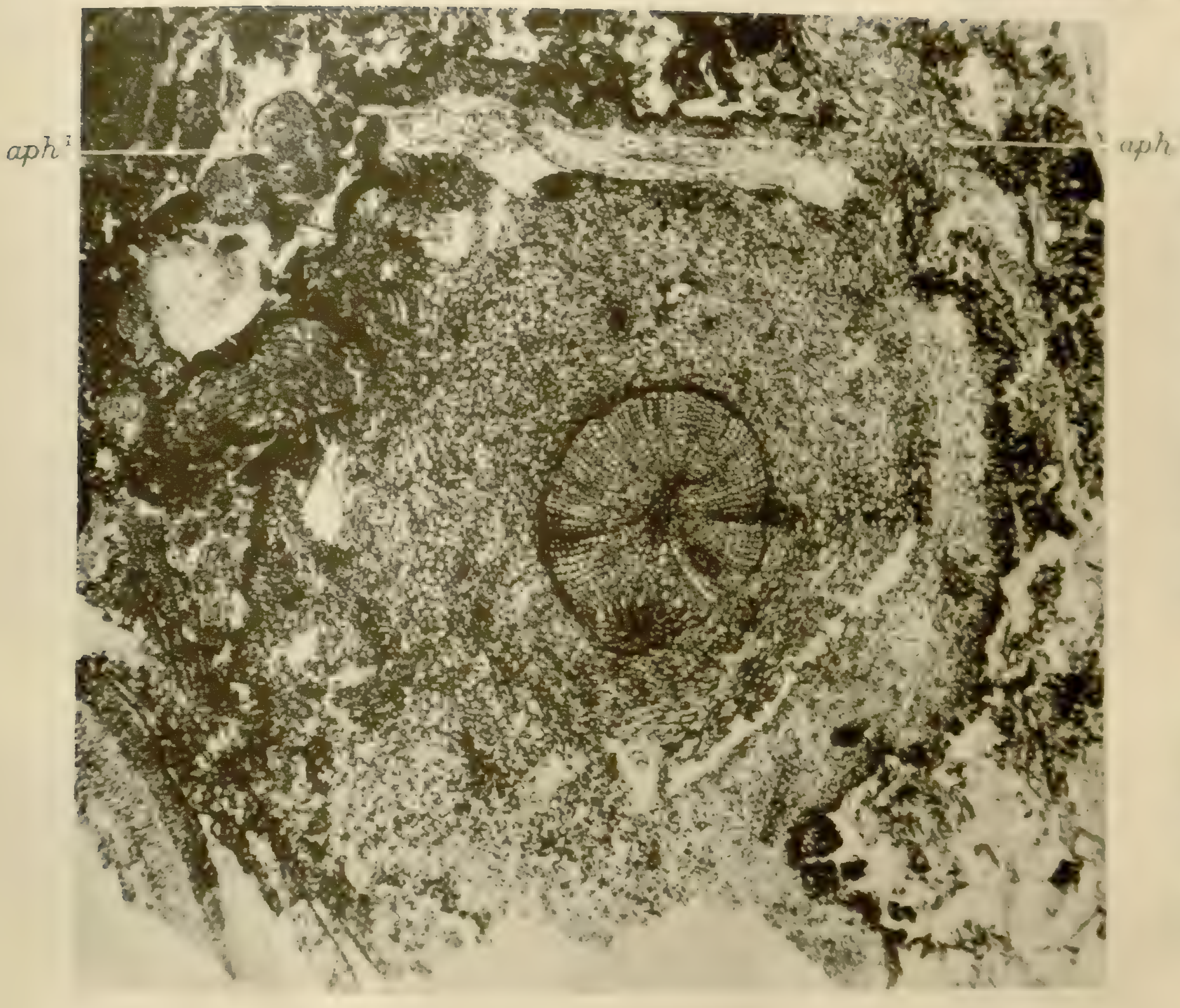
Fig. 20. Inner part of stele shown in fig. 7. *x.i.*, internal xylem; *px.*, probable position of a protoxylem group; *p.*, parenchyma; $x.^2$, secondary xylem; *r.r.*, base of a root-strand. × 100. Slide 2464.

21. Tracheides of the secondary wood in radial section. × 180. Slide 2462.

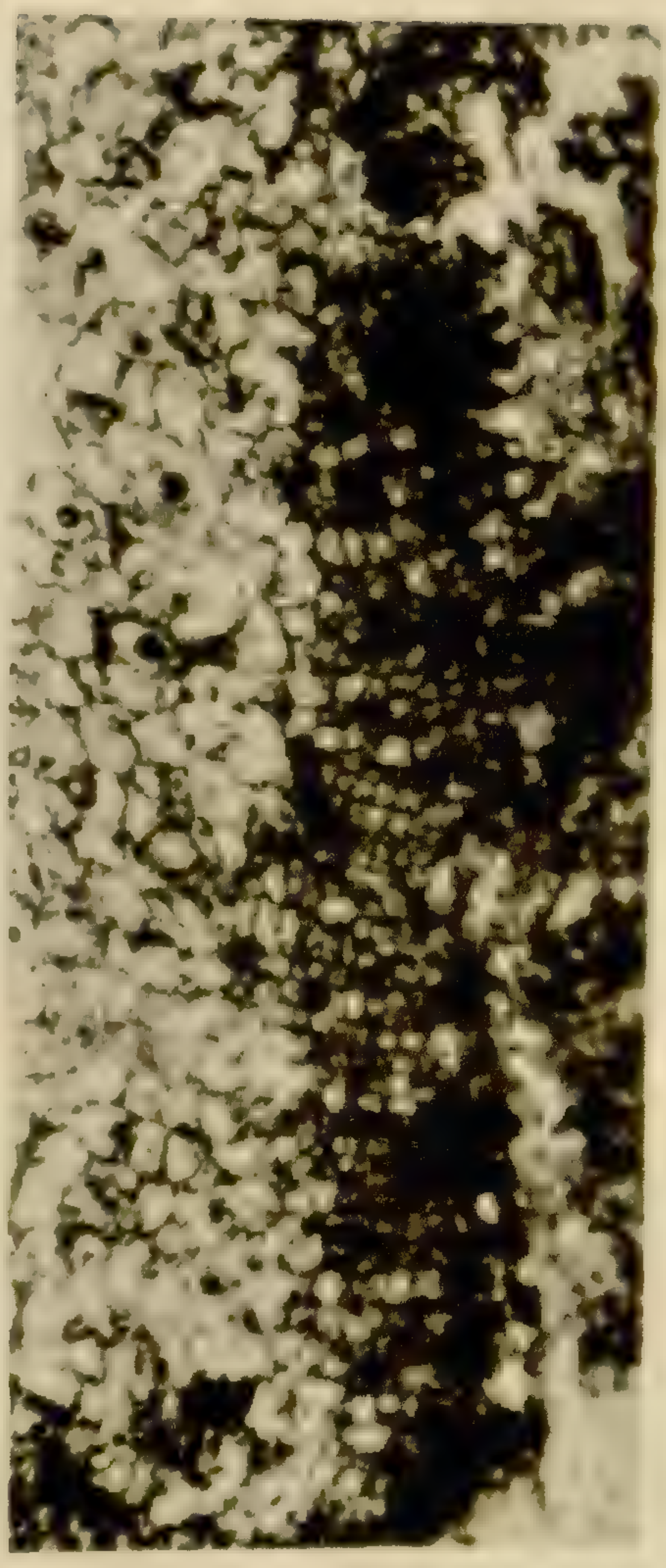
22. Longitudinal section through "mixed pith." *x.i.*, tracheides of internal xylem; *p.*, parenchyma; $x.^2$, secondary tracheides. × 100. Slide 2462.

23. Transverse section of petiolar bundle, shown in fig. 11. *x.x.*, ends of the xylem-band, showing incipient antennæ; *ph.*, phloem; *en.*, probable endodermis. Many of the tracheides, especially in the middle of the "apolar," are immature. × 100. Slide 2464.

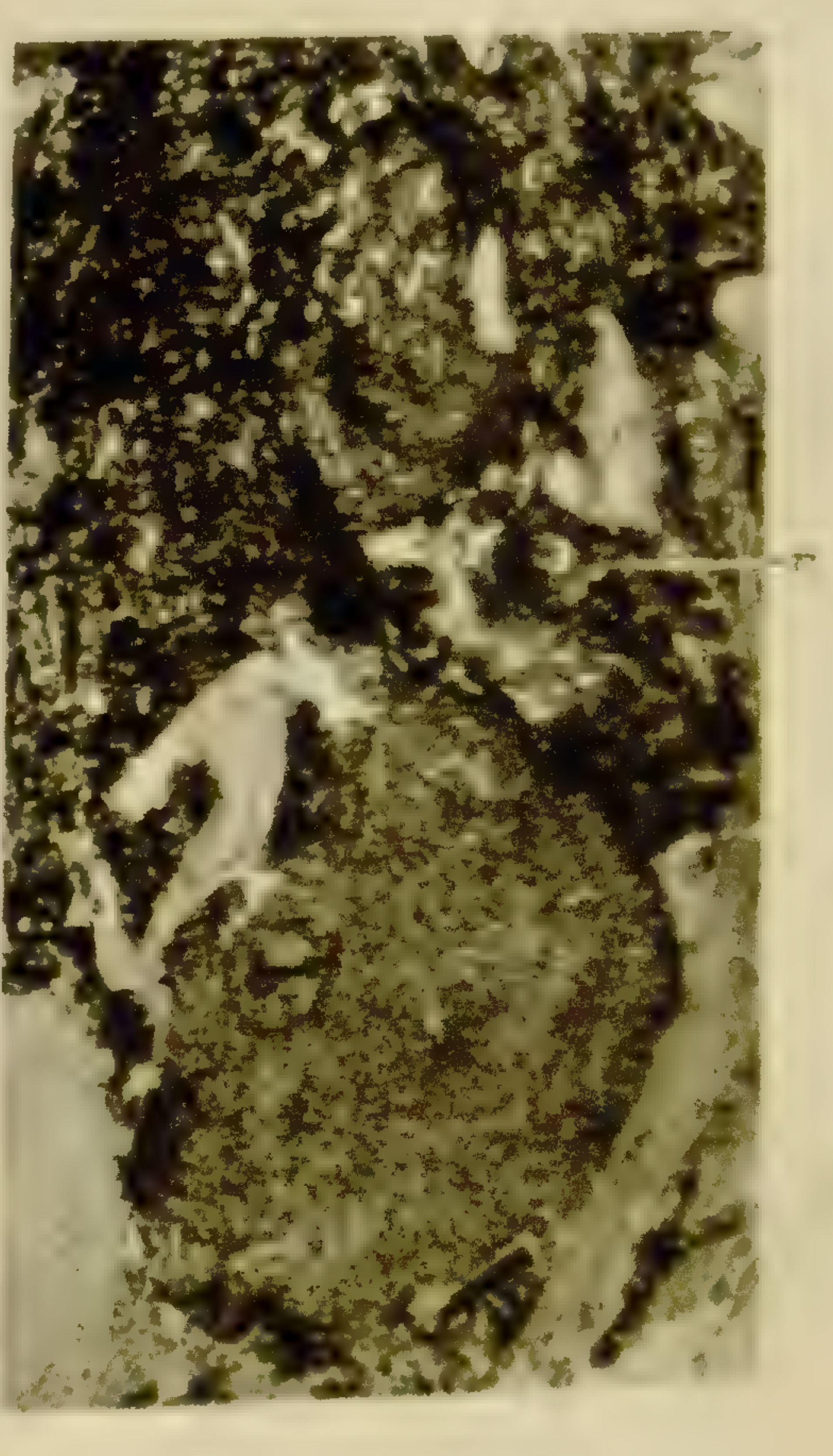
24. Transverse section of petiolar bundle from the next section above, shown in figs. 12 & 13. *s.*, *s.*, sinus at each end of xylem; *x.a.*, antennæ of the xylem. × 110. Slide 2465.



1.



3.

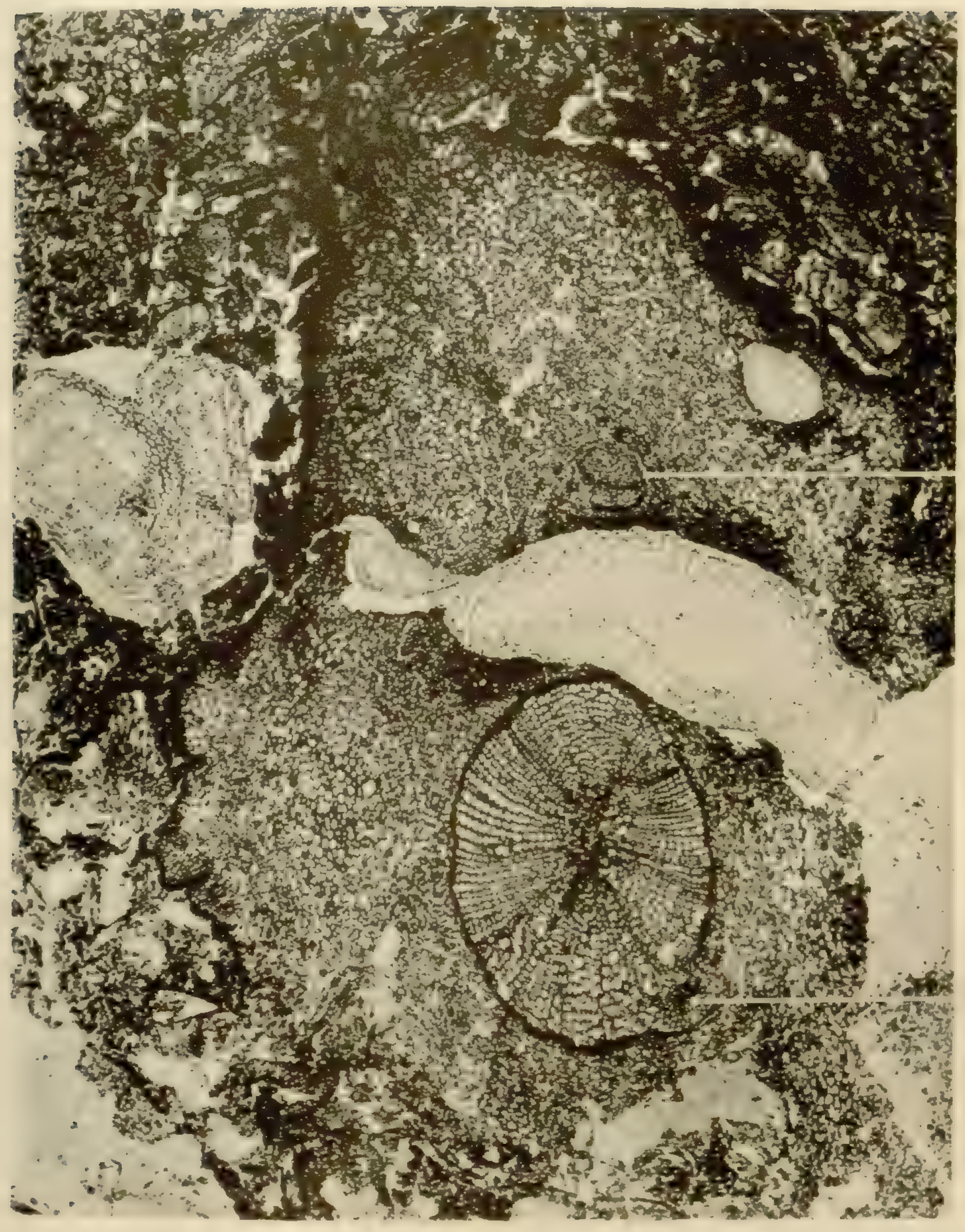


4.

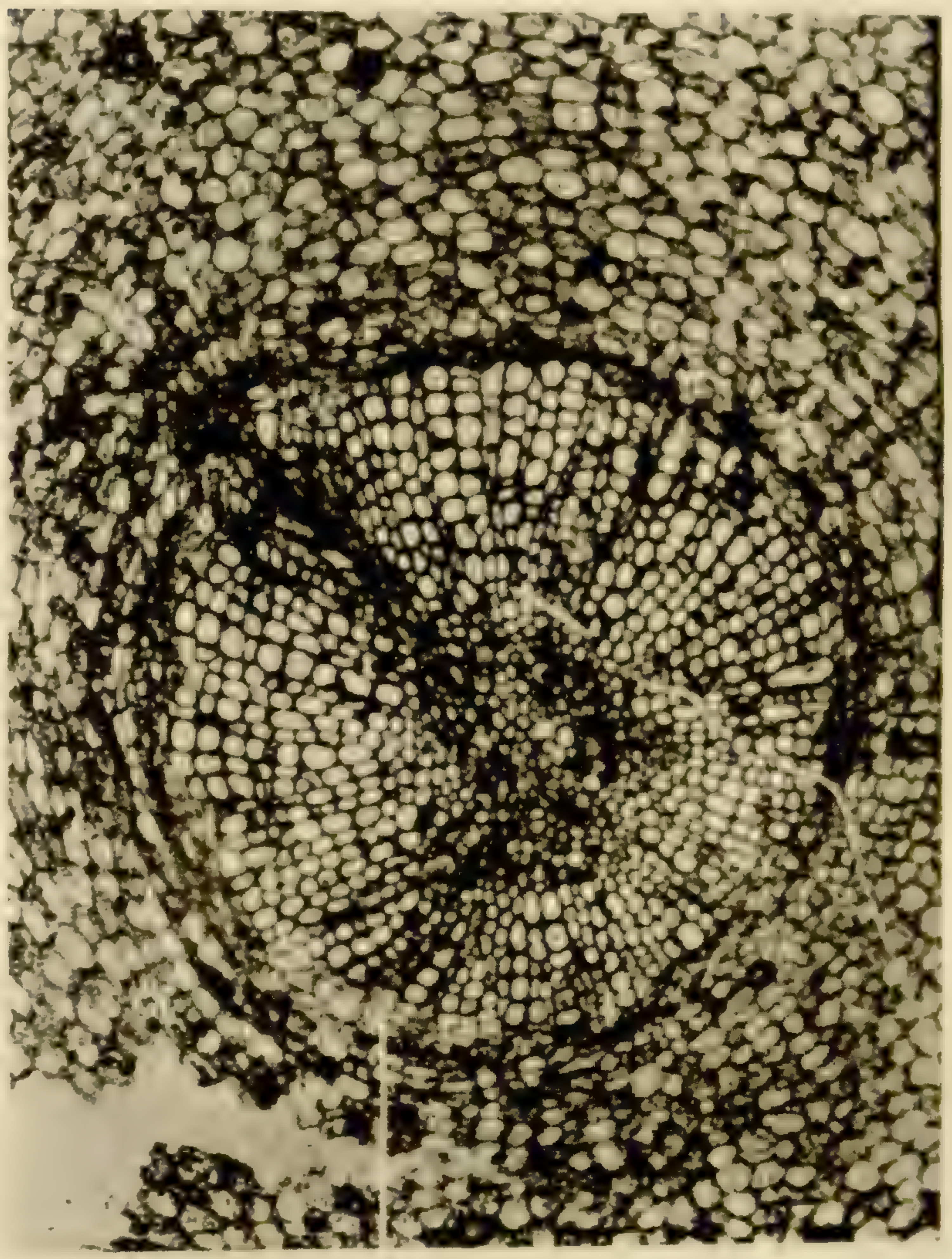
W Tams phot.

2.

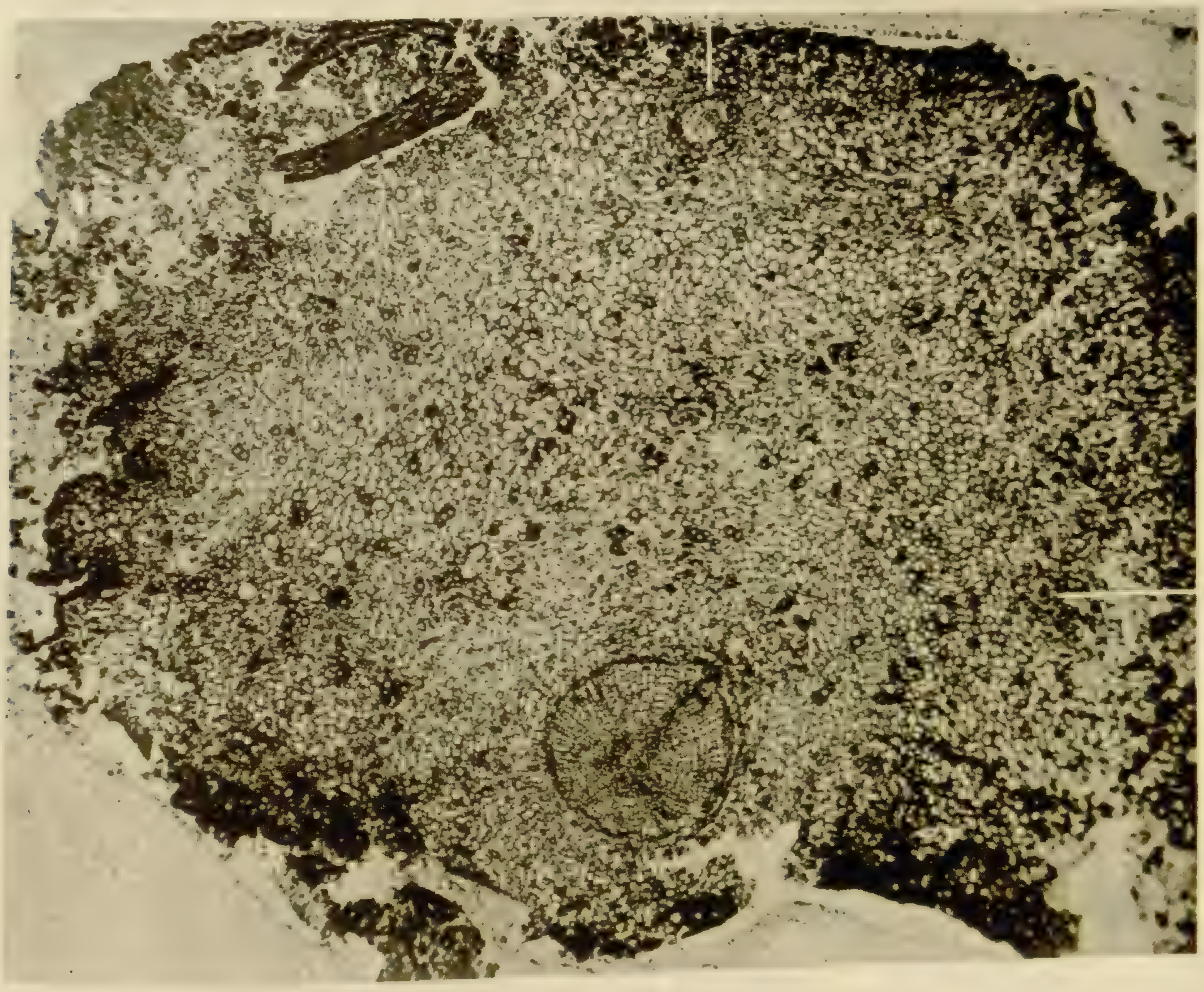
BOTRYCHIOXYLON PARADOXUM



5.



7.

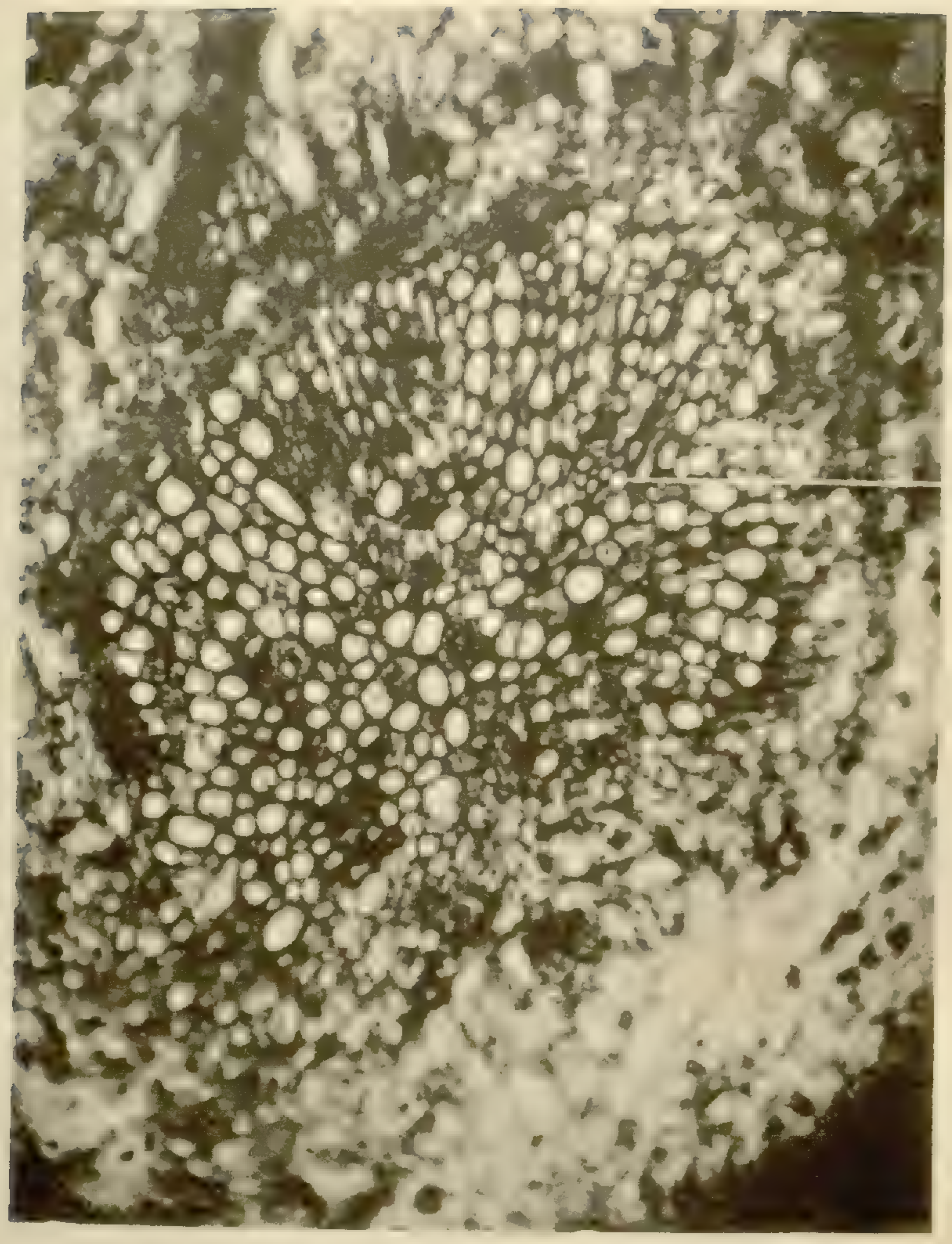


6.

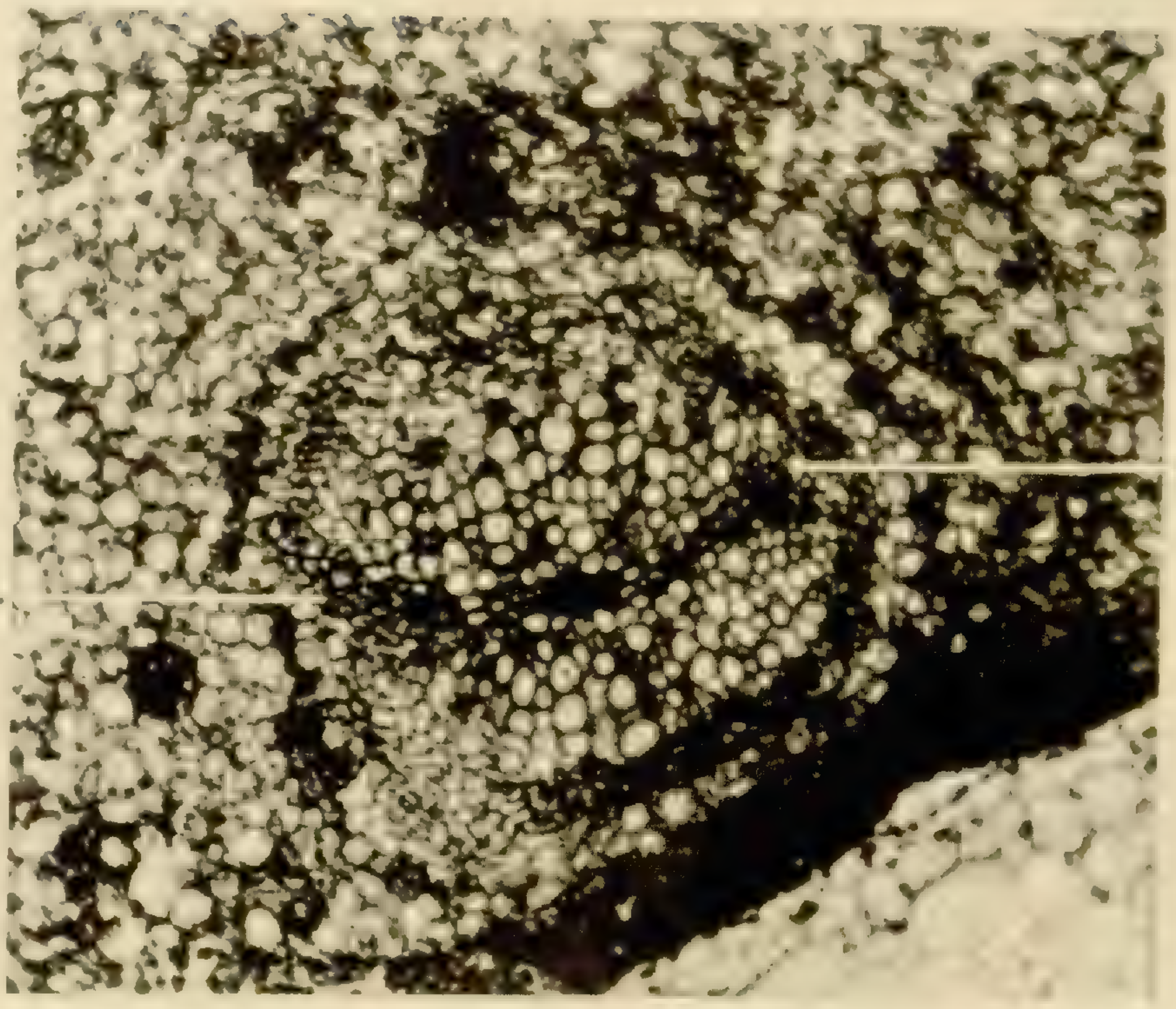
Tams, Lomax & Boodle phot.

Huth coll.

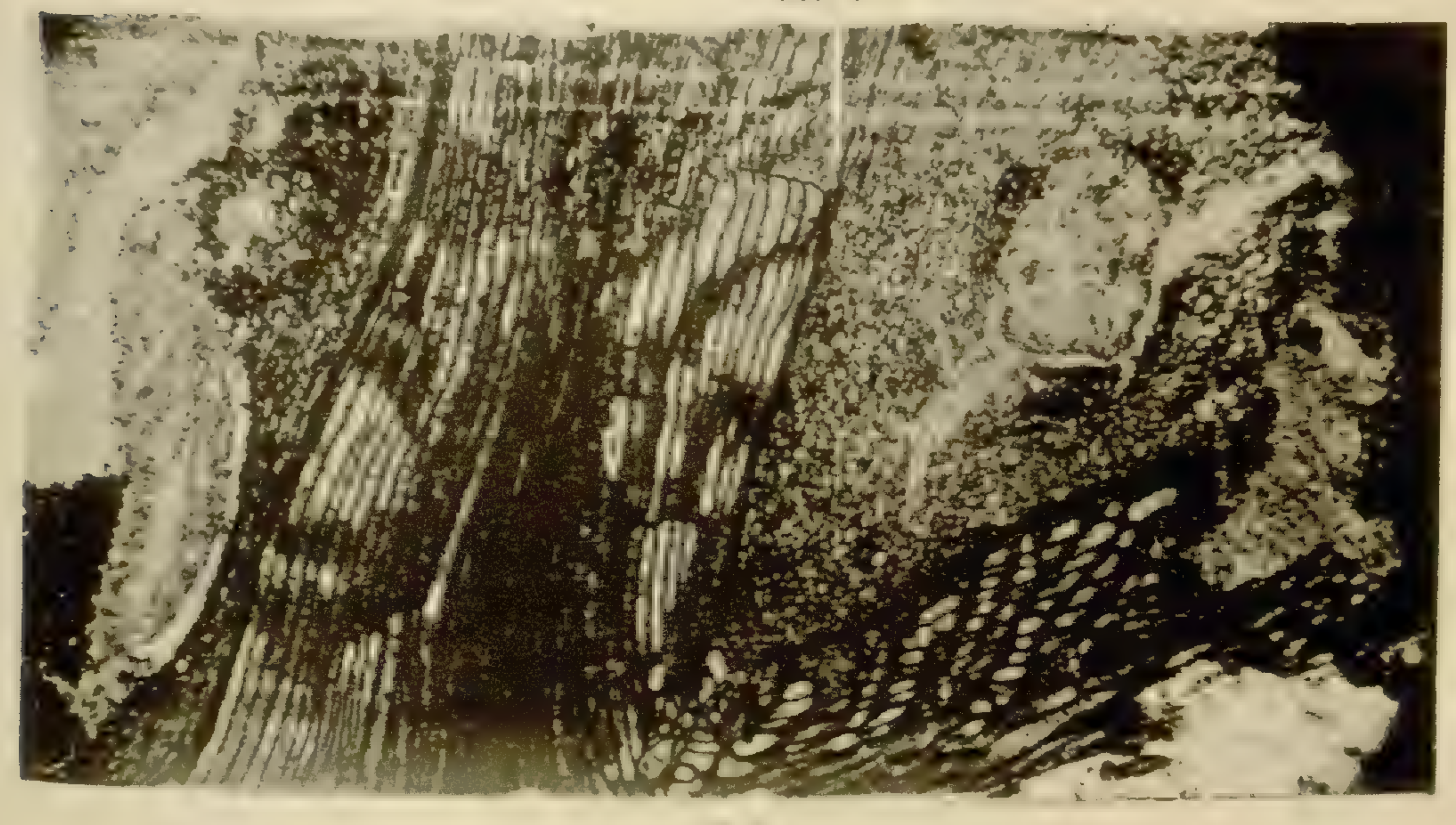
BOTRYCHIOXYLON PARADOXUM.



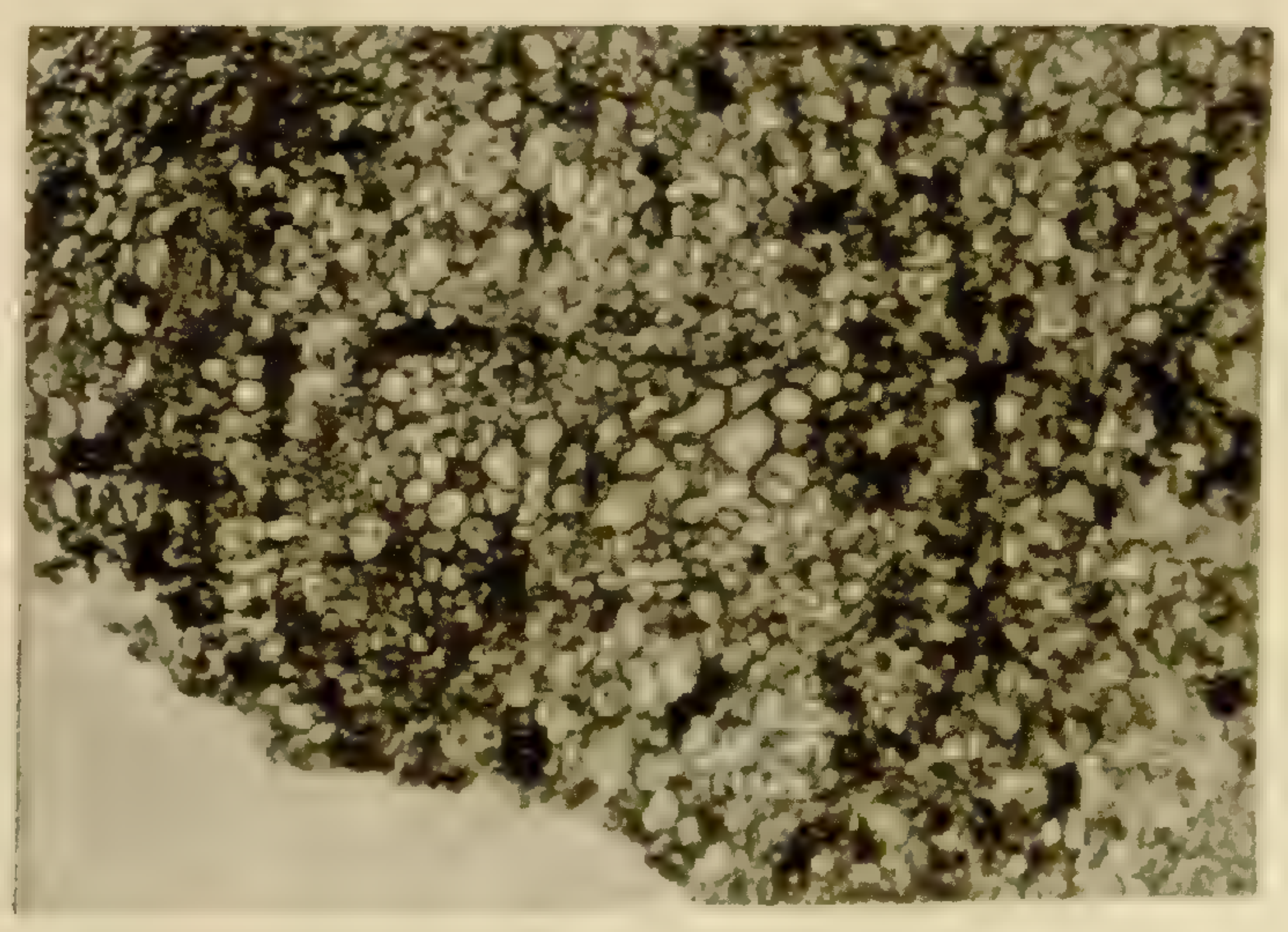
8.



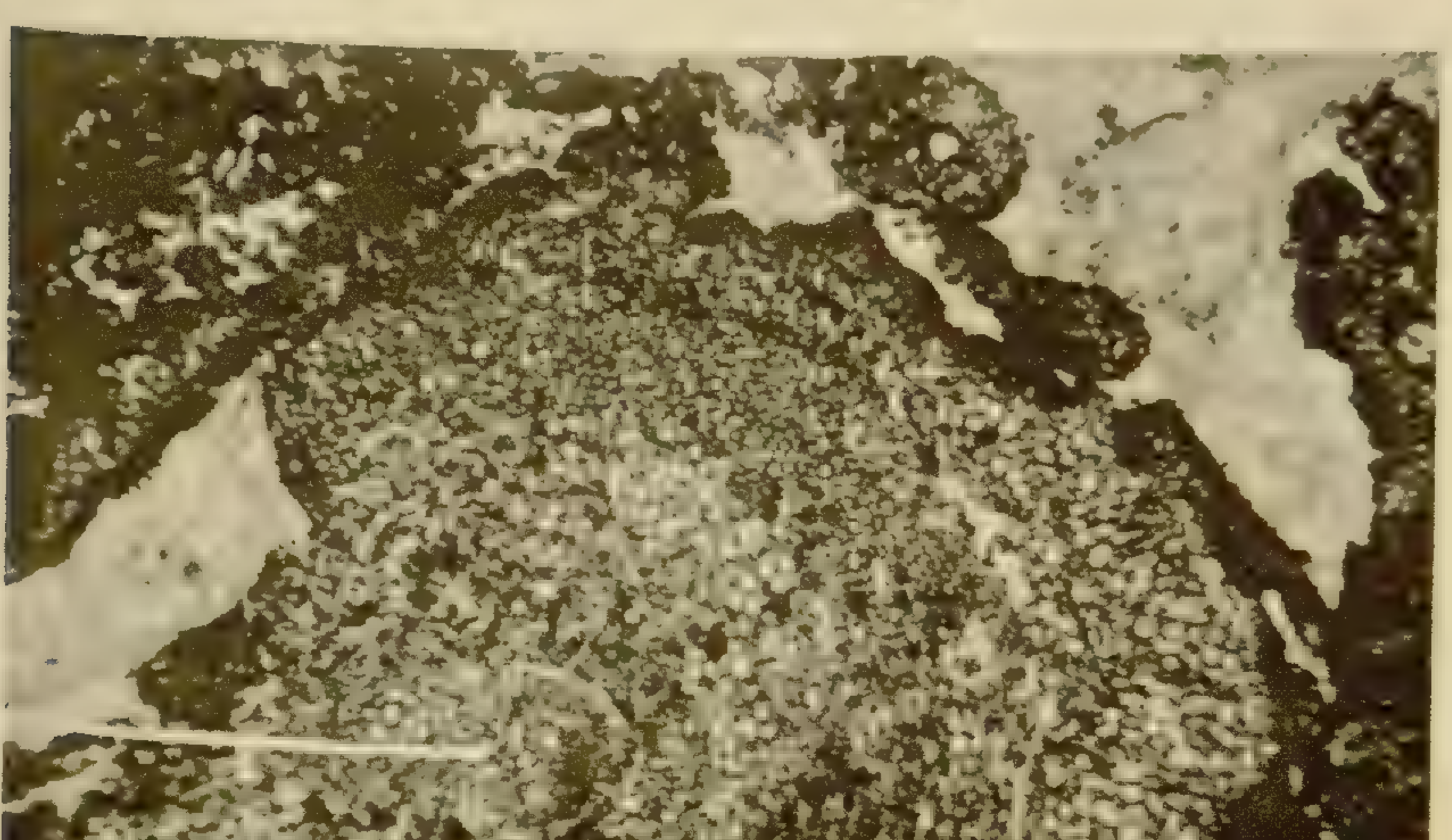
9.



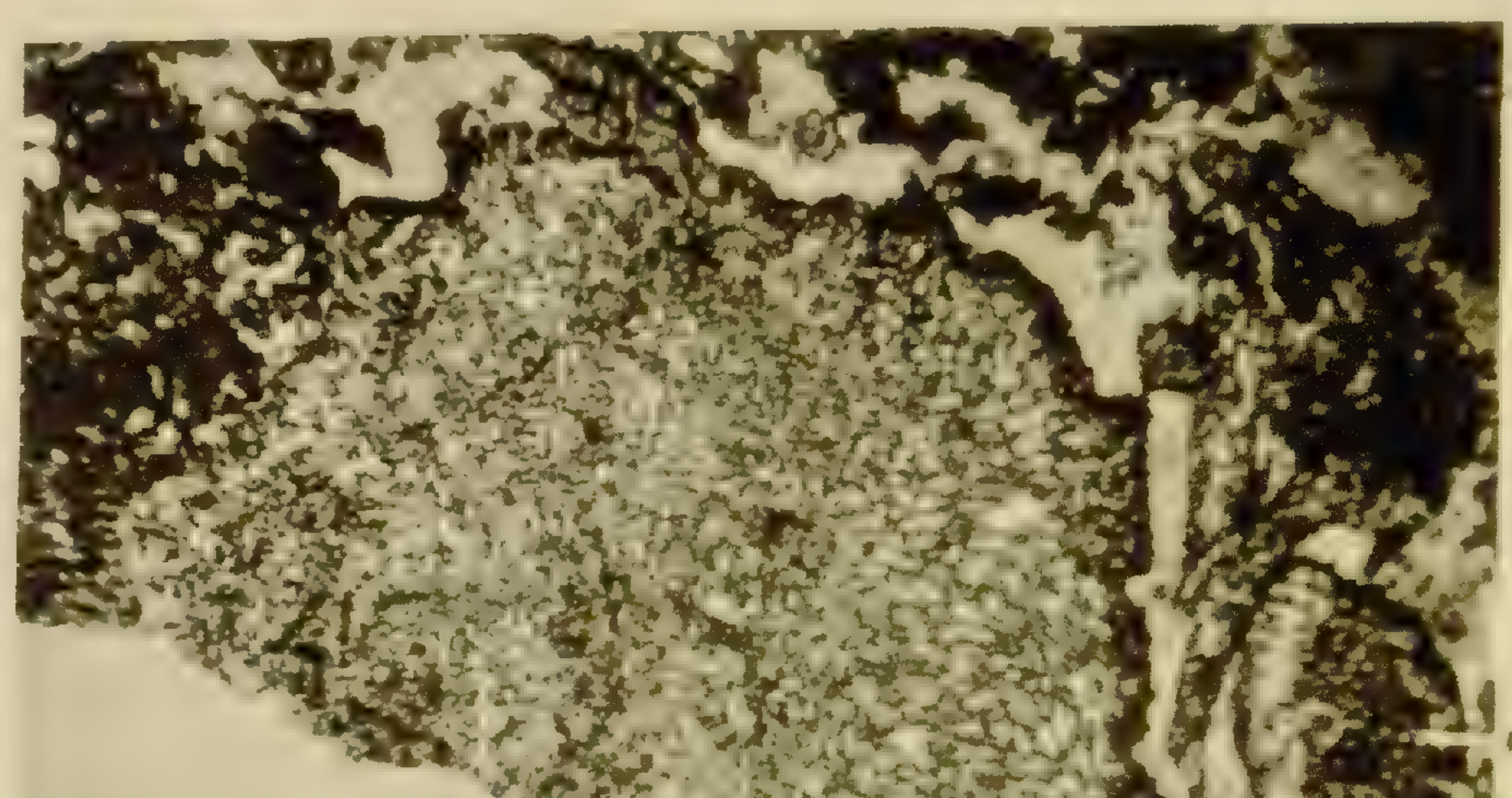
10.



13.



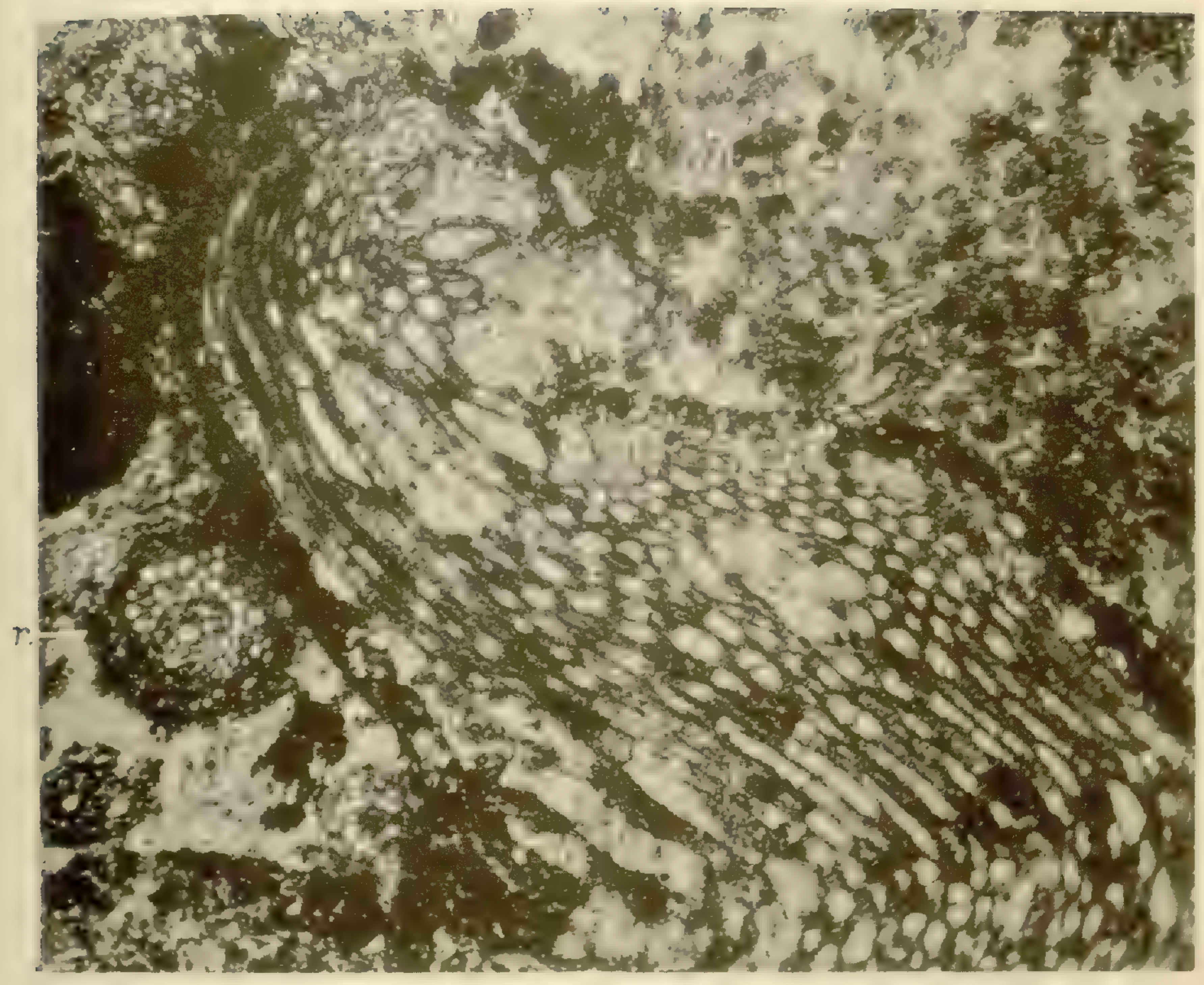
11.



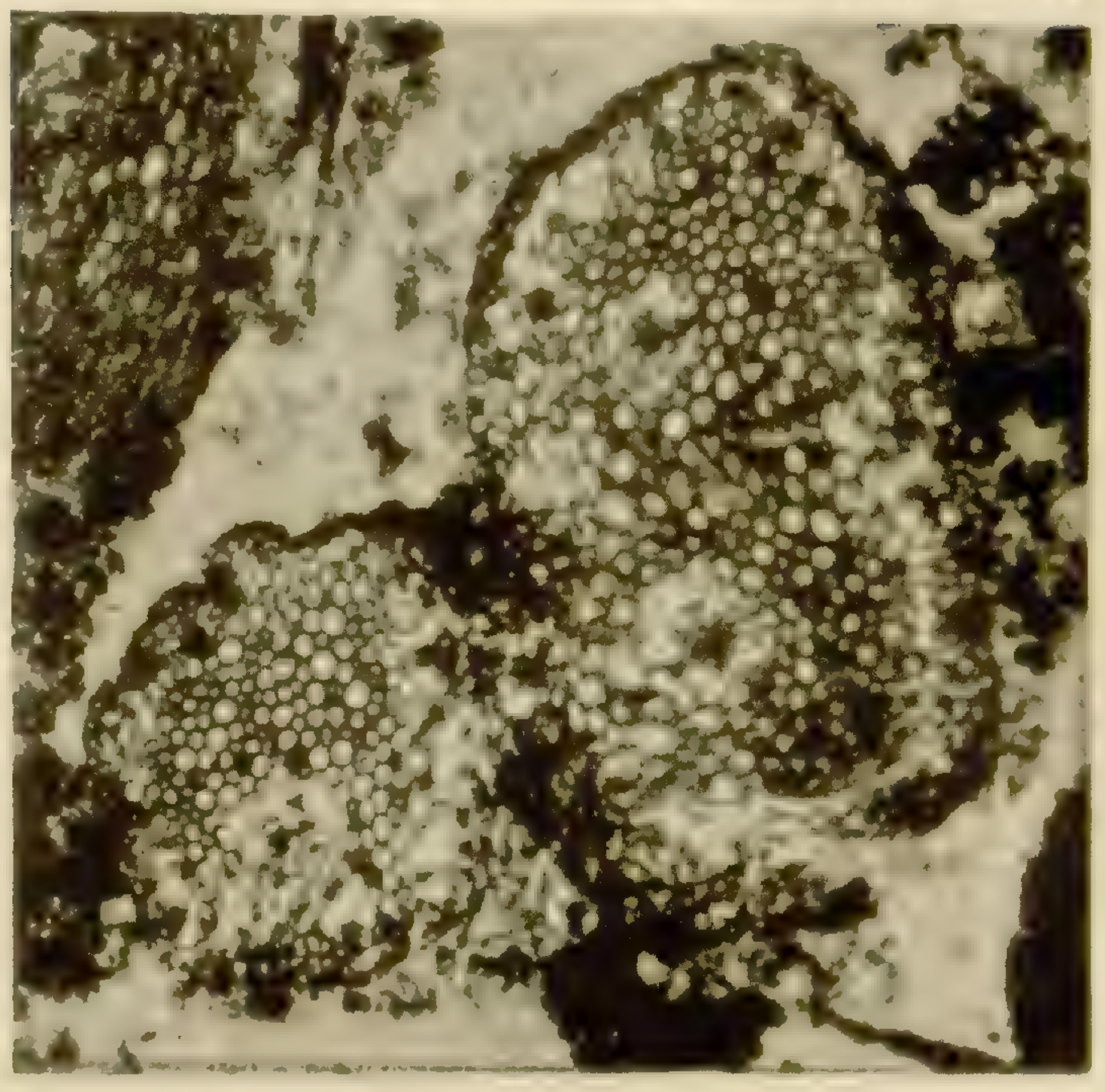
12.

Tams phot. Huth coll.

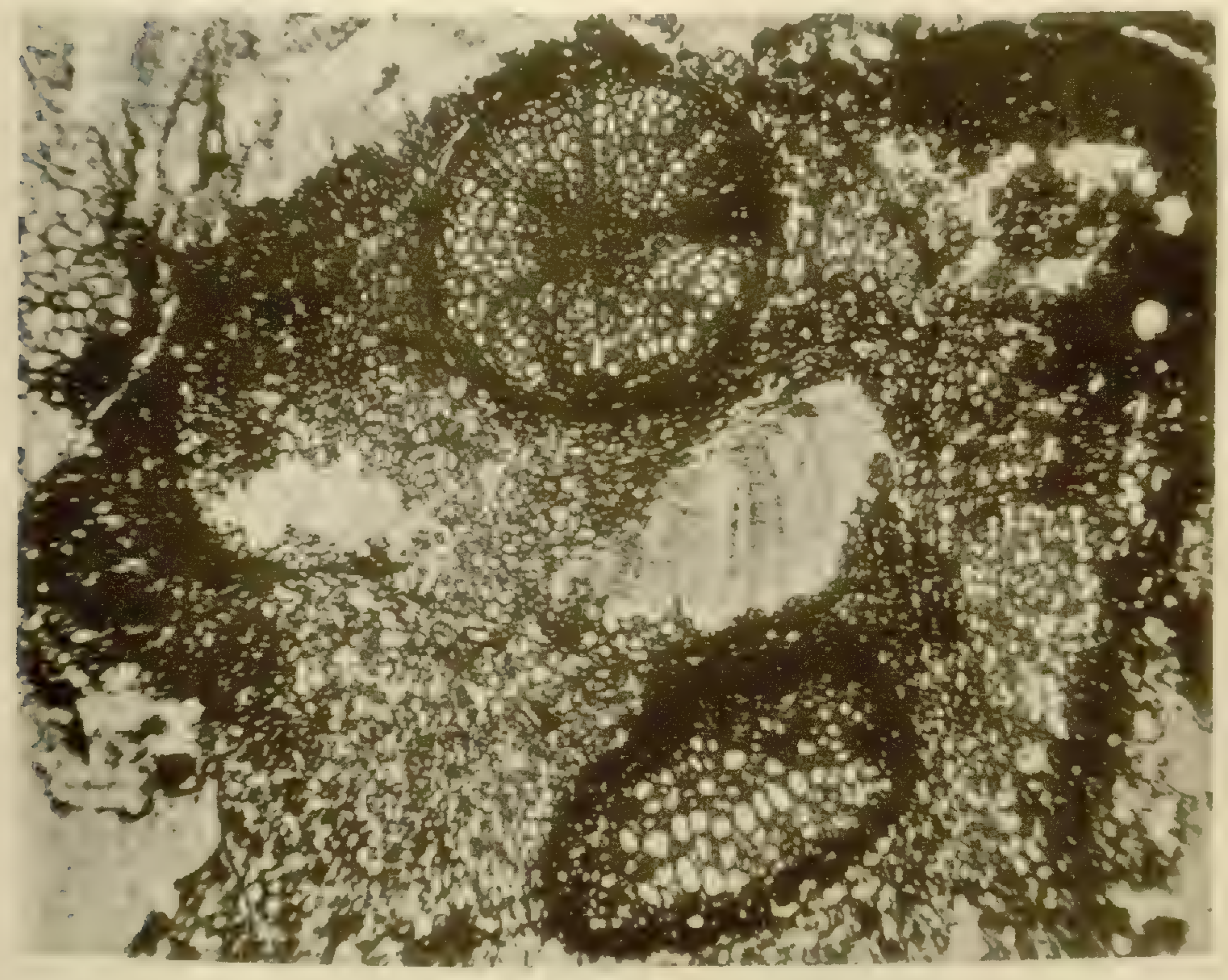
BOTRYCHIOXYLON PARADOXUM.



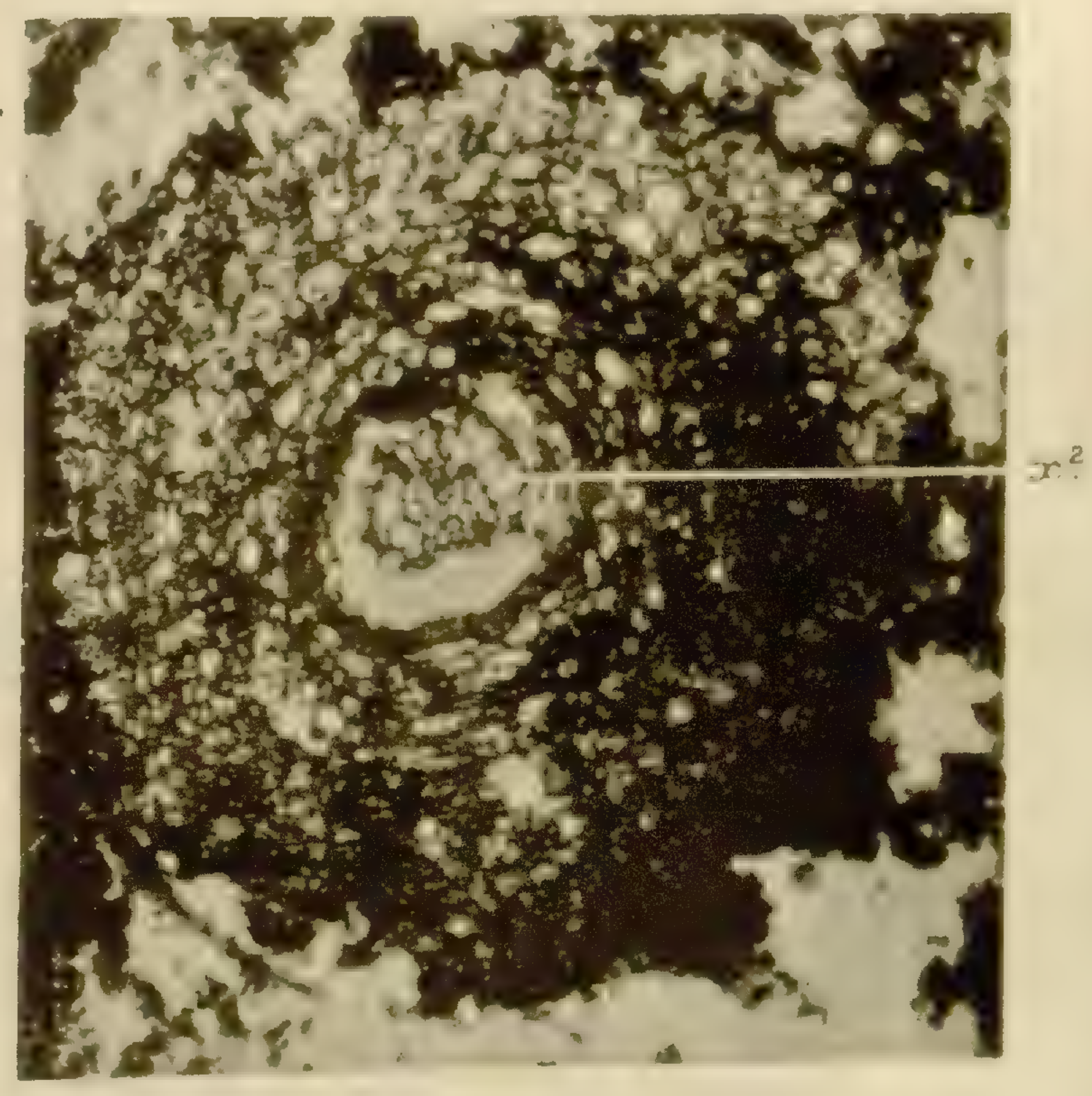
14.



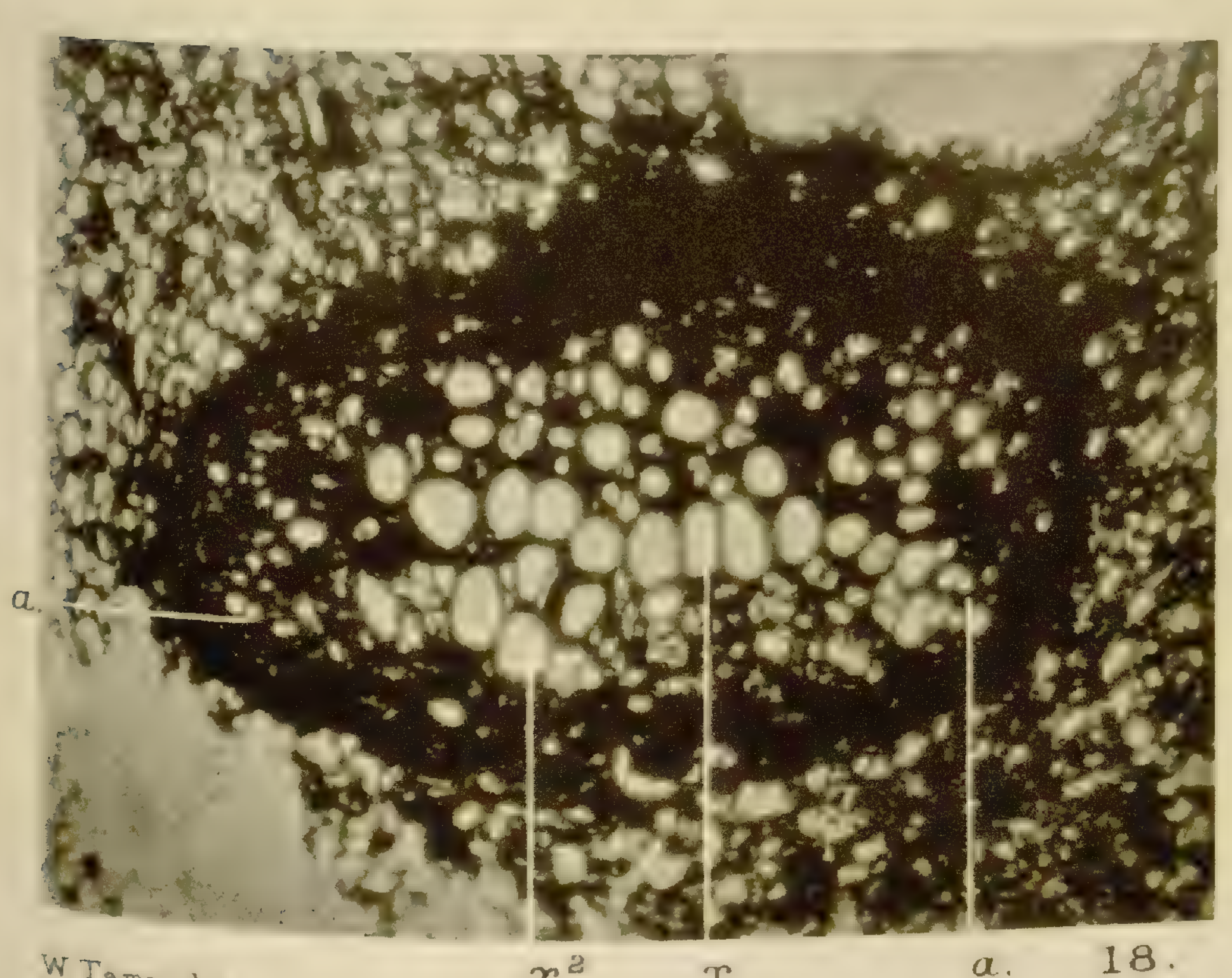
15.



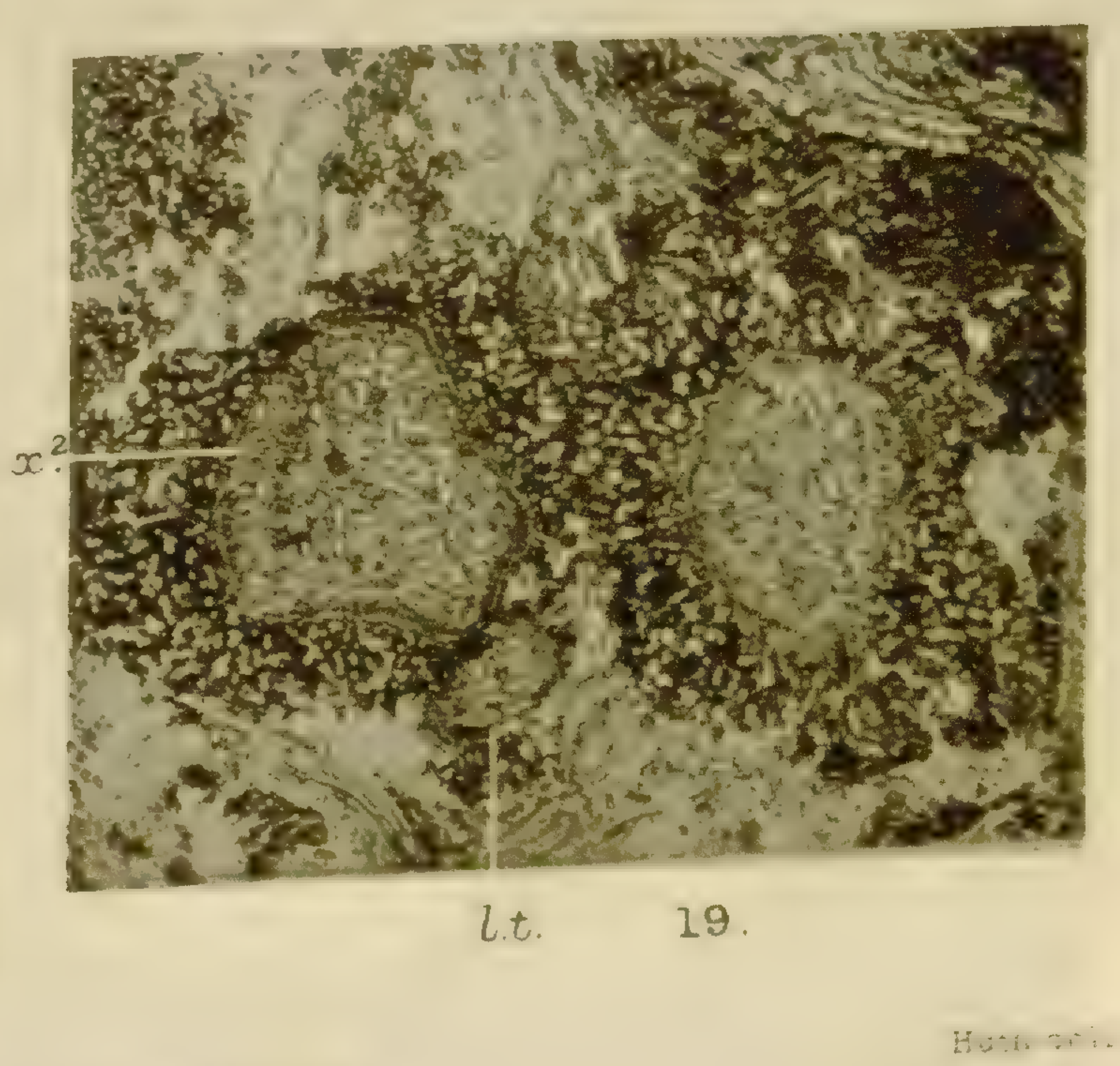
17.



16.



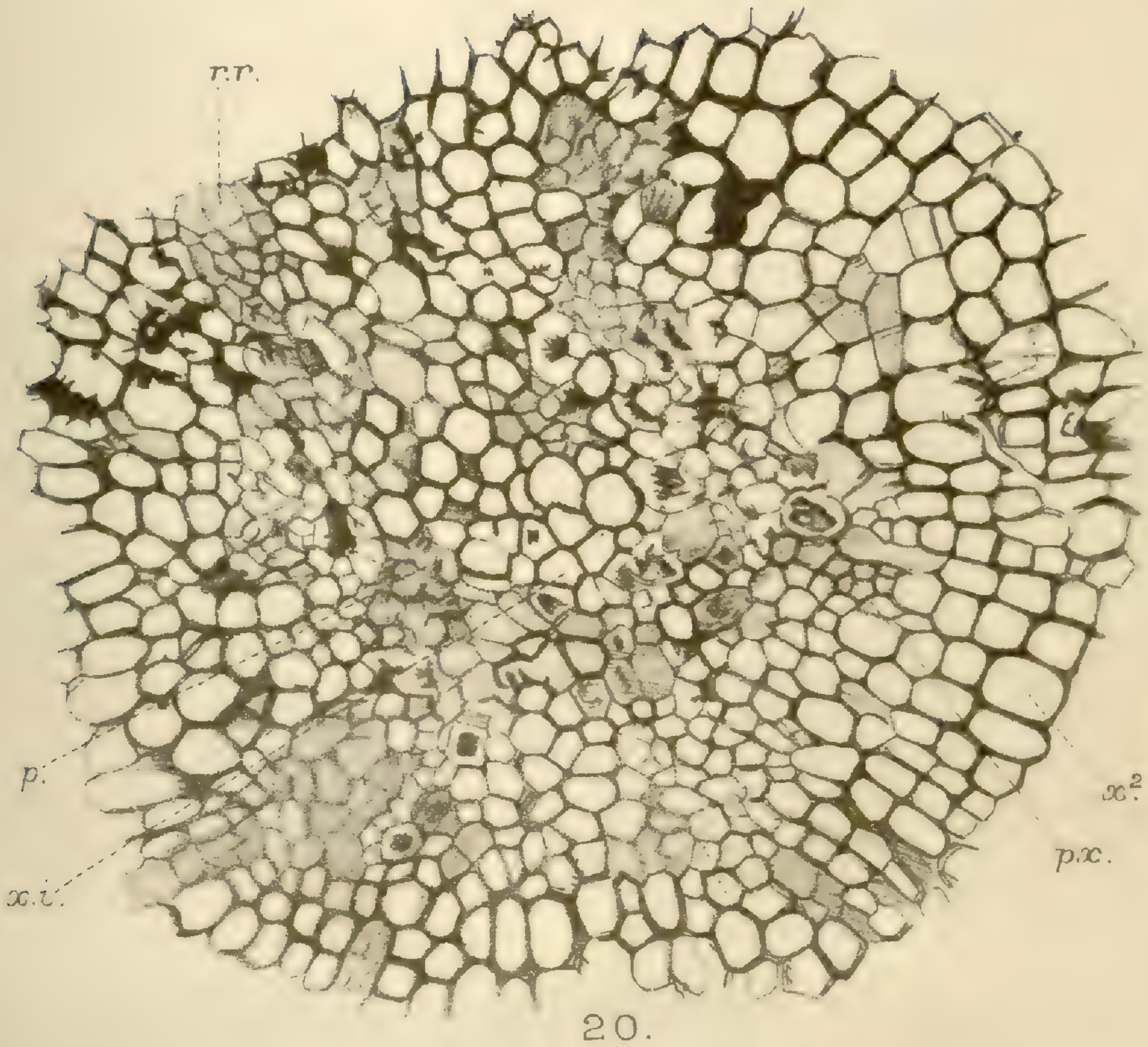
18.



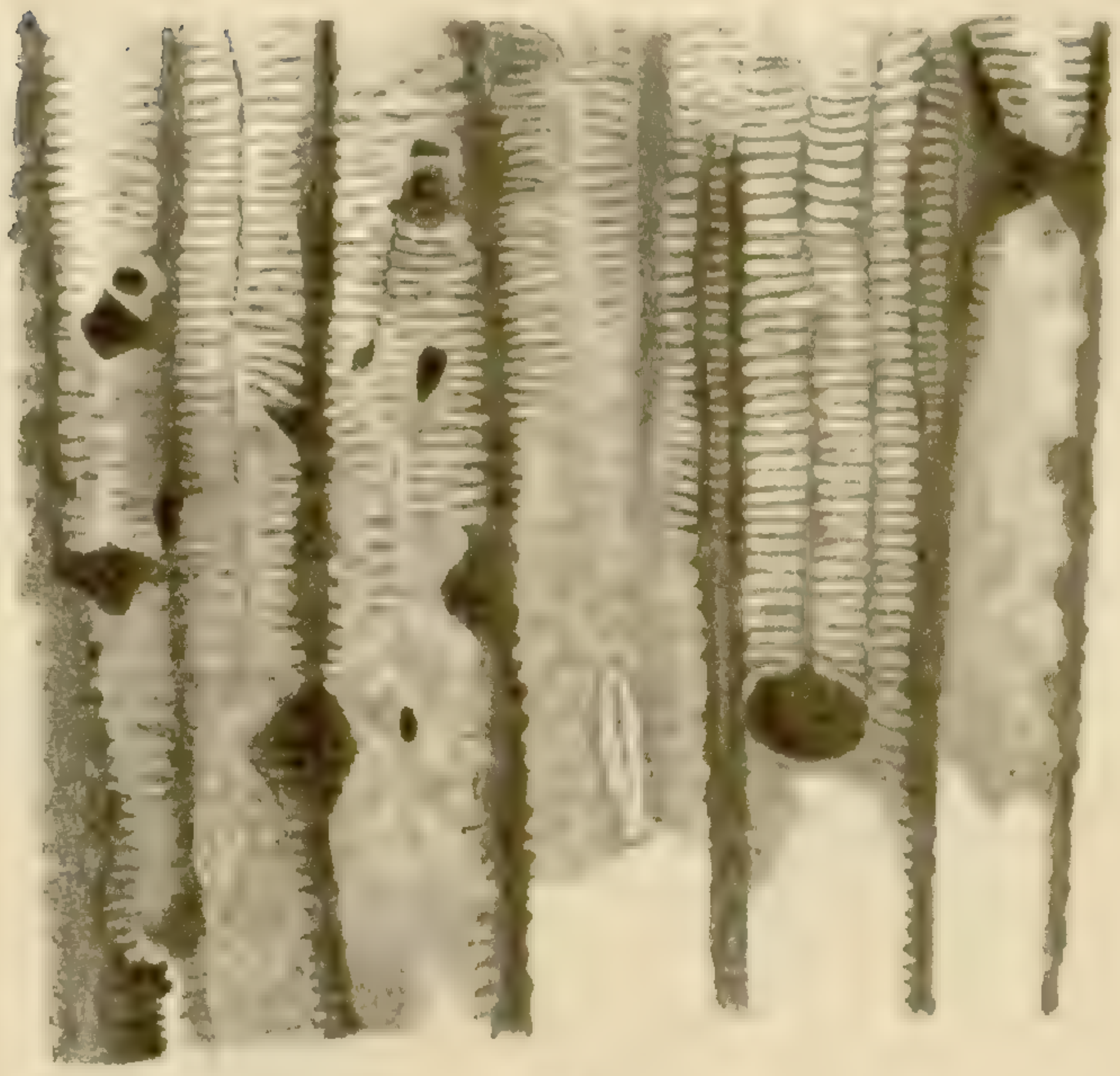
19.

W Tams phot.

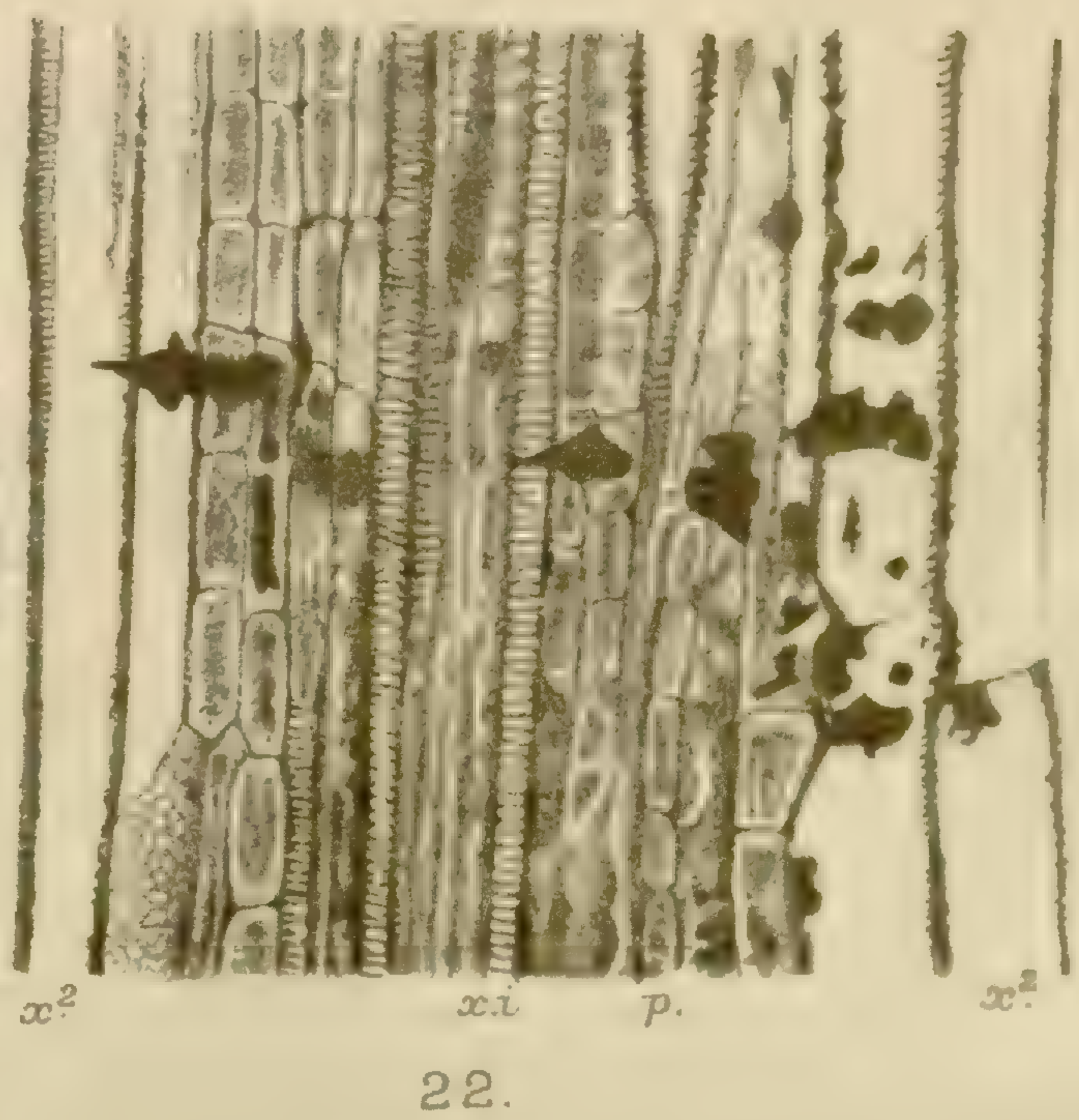
BOTRYCHIOXYLON PARADOXUM.



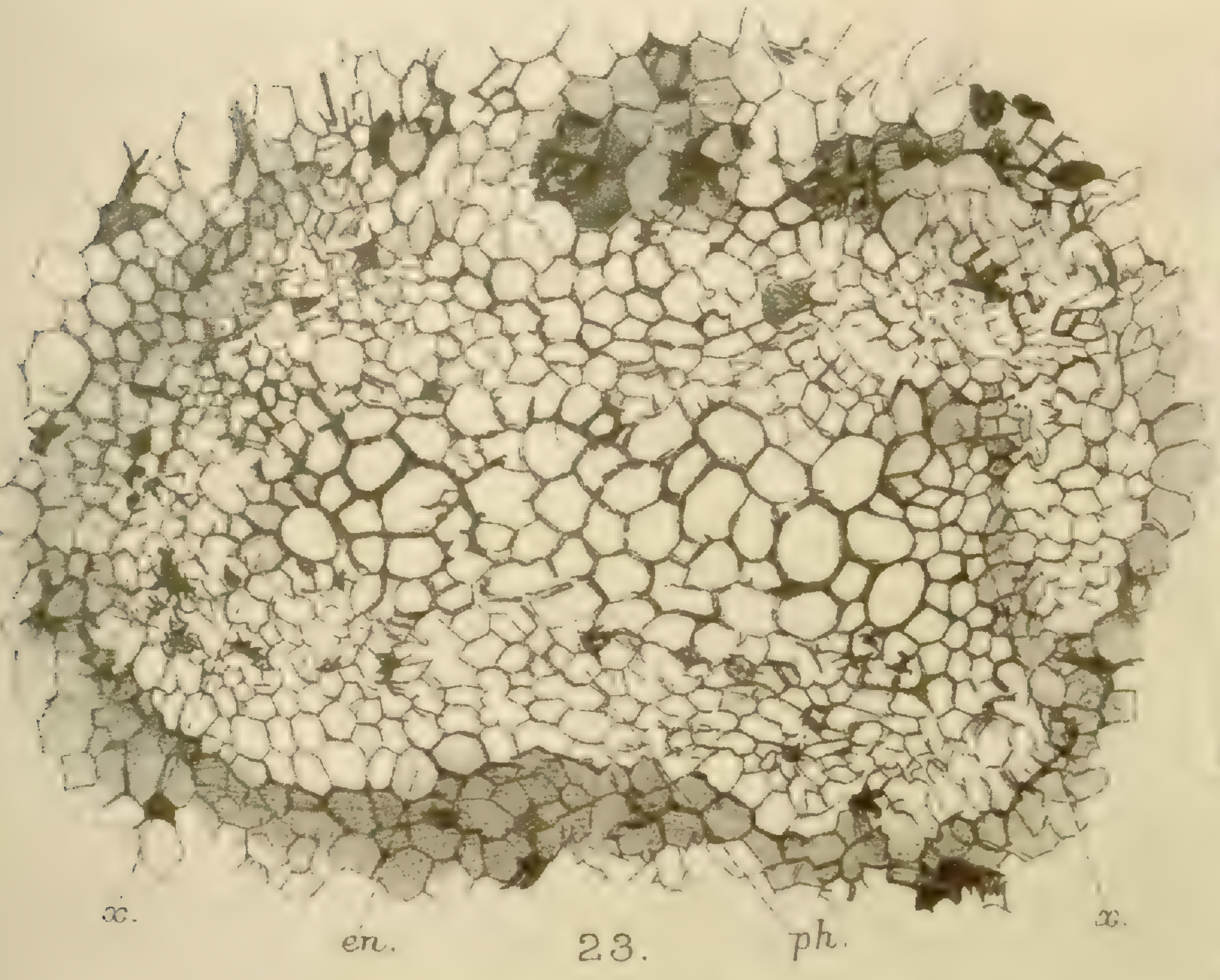
20.



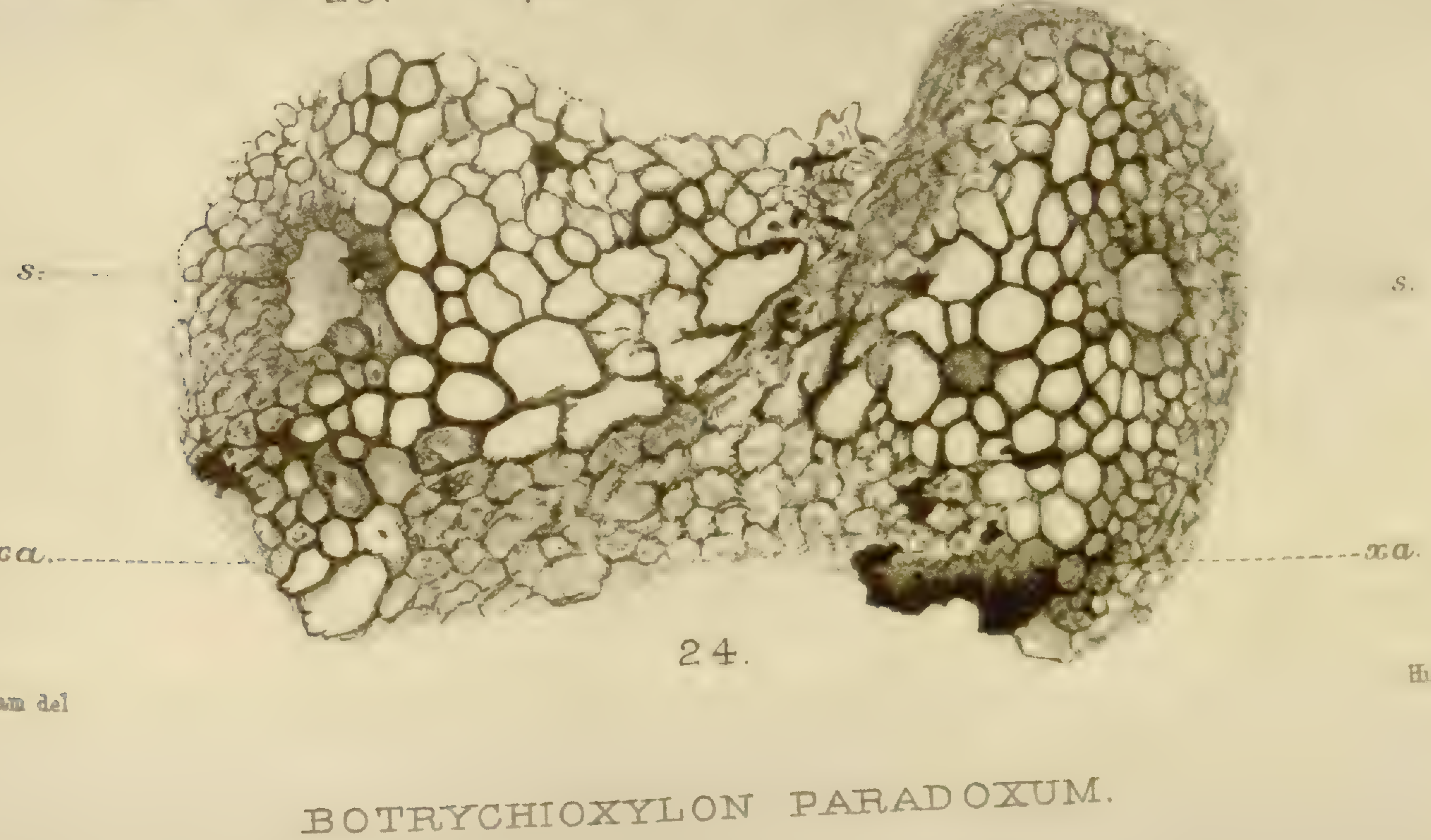
21.



22.



23.



24.

Harrison & Gwilliam del

Huth, Lith^r London.

BOTRYCHIOXYLON PARADOXUM.

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s.* to the public, and 6*s.* to Fellows; to Vols. 26–30, 4*s.* to the public, and 3*s.* to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

Second Series.—Botany.

Volume.	Part	When Published.	Price to the Public. £	*s.*	*d.*	Price to Fellows. £	*s.*	*d.*
I.	Parts I.–IX. (complete).	1875–80.	8	1	0	6	1	0
II.	Part I.	1881.	0	12	0	0	9	0
	Part II.	1882.	0	5	0	0	3	9
	Part III.	1883.	0	10	0	0	7	6
	Part IV.	1883.	0	3	0	0	2	3
	Part V.	1883.	0	3	0	0	2	3
	Part VI.	1884.	0	13	6	0	10	0
	Part VII.	1884.	0	9	6	0	7	0
	Part VIII.	1884.	0	10	0	0	7	6
	Part IX.	1886.	0	7	0	0	5	0
	Part X.	1887.	0	3	4	0	2	6
	Part XI.	1886.	0	6	0	0	4	6
	Part XII.	1886.	0	8	0	0	6	0
	Part XIII.	1887.	1	7	0	1	0	0
	Part XIV.	1887.	0	7	0	0	5	0
	Part XV.	1887.	0	10	0	0	7	6
	Part XVI.	1888.	0	2	6	0	2	0
III.	Part I.	1888.	3	12	0	2	14	0
	Part II.	1891.	0	5	0	0	3	9
	Part III.	1891.	0	7	0	0	5	0
	Part IV.	1891.	0	6	0	0	4	6
	Part V.	1891.	0	6	0	0	4	6
	Part VI.	1891.	0	3	6	0	2	8
	Part VII.	1892.	0	6	0	0	4	6
	Part VIII.	1893.	0	6	0	0	4	6
	Part IX.	1893	1	8	0	1	1	0
	Part X.	1894.	0	10	0	0	7	6
	Part XI.	1894.	0	3	4	0	2	6
IV.	Part I.	1894.	1	0	0	0	15	0
	Part II.	1894.	2	0	0	1	10	0
	Part III.	1895.	2	10	0	1	17	0
	Part IV.	1895.	0	3	4	0	2	6
V.	Part I.	1895.	0	9	0	0	6	9
	Part II.	1895.	0	12	0	0	9	0
	Part III.	1896.	0	6	0	0	4	6
	Part IV.	1896.	1	0	0	0	15	0
	Part V.	1896.	0	14	0	0	10	6

Second Series.—Botany (*continued*).

Volume.	Part	When Published.	Price to the Public. £	*s.*	*d.*	Price to Fellows. £	*s.*	*d.*
V.	Part VI.	1896.	0	4	0	0	3	0
	Part VII.	1897.	0	4	0	0	3	0
	Part VIII.	1897.	0	6	0	0	4	6
	Part IX.	1899.	0	12	0	0	9	0
	Part X.	1899.	0	6	0	0	4	6
	Part XI.	1899.	0	7	0	0	5	0
	Part XII.	1899.	0	12	0	0	9	0
	Part XIII.	1900.	0	1	6	0	1	2
	Part XIV.	1900.	0	3	0	0	2	3
	Part XV.	1901.	0	6	0	0	4	6
VI.	Part I.	1901.	1	10	0	1	2	6
	Part II.	1901.	0	6	0	0	4	6
	Part III.	1902.	0	18	0	0	13	6
	Part IV.	1903.	0	8	0	0	6	0
	Part V.	1903.	0	8	0	0	6	0
	Part VI.	1903.	0	12	0	0	9	0
	Part VII.	1904.	0	12	0	0	9	0
	Part VIII.	1904.	0	12	0	0	9	0
	Part IX.	1904.	0	7	0	0	5	3
	Part X.	1904.	0	14	0	0	10	6
	Part XI.	1905.	0	4	0	0	3	0
VII.	Part I.	1904.	0	5	0	0	3	9
	Part II.	1905.	0	6	0	0	4	6
	Part III.	1906.	0	3	0	0	2	3
	Part IV.	1906.	0	7	0	0	5	3
	Part V.	1907.	0	10	0	0	7	6
	Part VI.	1907.	0	4	0	0	3	0
	Part VII.	1907.	0	6	0	0	4	6
	Part VIII.	1908.	0	5	0	0	3	9
	Part IX.	1908.	0	2	6	0	2	0
	Part X.	1908.	0	7	0	0	5	3
	Part XI.	1909.	0	4	0	0	3	0
	Part XII.	1909.	0	12	0	0	9	0
	Part XIII.	1909.	0	5	0	0	3	9
	Part XIV.	1909.	0	6	0	0	4	6
	Part XV.	1910.	0	6	0	0	4	6
	Part XVI.	1912.	0	3	0	0	2	3
	Part XVII.	1912.	0	8	0	0	6	0

2nd Ser. BOTANY.] [VOL. VII. PART 18.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

ON PSYGMOPHYLLUM MAJUS, SP. NOV., FROM THE LOWER CARBONIFEROUS ROCKS OF NEWFOUNDLAND, TOGETHER WITH A REVISION OF THE GENUS AND REMARKS ON ITS AFFINITIES.

BY

E. A. NEWELL ARBER, M.A., Sc.D., F.L.S., F.G.S.

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

July 1912.

XVIII. *On* Psygmophyllum majus, *sp. nov., from the Lower Carboniferous Rocks of Newfoundland, together with a Revision of the Genus and Remarks on its Affinities.*

By E. A. Newell Arber, *M.A., Sc.D., F.L.S., F.G.S., Trinity College, Cambridge; University Demonstrator in Palæobotany.*

(Plates 42–44 and 1 Text-figure.)

Read 18th April, 1912.

Contents.

	Page
1. Introduction	391
2. *Psygmophyllum majus*, sp. nov.	392
3. *Psygmophyllum flabellatum* (Lindl. & Hutt.)	394
4. A Revision of the Genus *Psygmophyllum*	397
5. A Discussion of the Affinities of *Psygmophyllum*	403
6. Bibliography	405
7. Explanation of the Plates	407

1. Introduction.

In 1908, several remarkable fossil plant-impressions from Newfoundland were presented to the Sedgwick Museum, Cambridge, by Mr. Rowland Feilding. They had been collected during the previous year from the Shenanditti River, on the west side of Red Indian Lake, in the interior of that colony. The specimens have proved to be of considerable interest, both on account of their excellent preservation and also because one of the genera represented is exceedingly rare. Further, since very few fossil plants of any age have hitherto been recorded from Newfoundland, they form a welcome addition to our knowledge of the past floras of that country.

The specimens include representatives of two species, one of which appears to be new, and to be referable to the rare and little-known genus *Psygmophyllum*. Several examples of this plant will be described here under the name *P. majus*, sp. nov. The other plants are identical with *Sphenophyllum tenerrimum*, Stur (Pl. 44. fig. 12). Both stems and whorls of leaves are found, examples of which I have already figured in 1910 *. Some of them occur on the same slabs of shale as *P. majus*. These fossils afford the sole evidence which we have at present in regard to the age of the beds in which they occur. This species is recorded from the Lower Carboniferous of Silesia, and closely similar plants are known from the Upper Devonian of Bear Island, and from beds believed to be of similar age in the State of Maine, U.S.A. The geological age of the rocks is therefore either Lower Carboniferous or Upper Devonian, more probably the former. Thin seams of coal were found associated with the plant-bearing shales

* Arber ('10), text-figs. 1 & 2.

in Newfoundland, and this fact, in addition to their excellent preservation which is a rare feature among Devonian plants, favours the conclusion that the beds are of Lower Carboniferous age.

I have also had opportunities of examining some examples of the British representative of the genus, *Psygmophyllum flabellatum* (Lindl. & Hutt.), a very rare Coal-Measure plant, known only from this country and from a single coalfield. As no detailed account of this species has been published, beyond the brief diagnoses given by Lindley and Hutton, Schimper and Renault, I have added a full description of it here. I have also taken the opportunity of revising the genus as a whole, so that the present communication is practically a monograph of the subject.

Finally, I have ventured to conclude with some discussion on the affinities of *Psygmophyllum*, so far as it is possible to arrive at any provisional views on these fossils at the present time.

I desire to express my obligations to those who have kindly lent me specimens of *P. flabellatum* (Lindl. & Hutt.). In particular, I would express my indebtedness to the Council of the Sunderland Public Museum, who, through the kind offices of the Director, Mr. J. A. Charlton Deas, F.R.Hist.S., and his assistant, Mr. G. H. Dutton, have lent me their valuable series of specimens of this fossil. I am likewise under obligations to the Council of the Hancock Museum, Newcastle-on-Tyne, who, through their Curator, Mr. E. L. Gill, M.Sc., have lent me specimens from the Hutton Collection. To my friend Professor Nathorst I would return my thanks for the photograph of his type-specimen of *P. Williamsoni* in the Stockholm Museum, which he has kindly allowed me to reproduce here.

2. PSYGMOPHYLLUM MAJUS, sp. nov.

(Pl. 42. fig. 1; Pl. 43. figs. 5, 6; Pl. 44. fig. 9.)

1910. *Psygmophyllum* sp., Arber, Proc. Camb. Phil. Soc. vol. xv. p. 391.

Diagnosis.—Leaves flabellate, large, often exceeding 16 cm. in length and 15 cm. in breadth, broadest at the apex, suddenly contracted below to a broad, elongate, ? sheathing base. Margins curved. Apex rounded, ? entire, or broadly lobed. Veins radiating from the base, with frequent dichotomy throughout the lamina, fairly distant, few in number below, and erect but not converging at the apex.

Type-specimens.—Nos. 2210–2215 and 2083 in the Carb. Plant Coll., Sedgwick Museum, Cambridge.

Description of the specimens.—The specimens consist of several fragmentary impressions of large, detached, fan-shaped leaves, occurring on slabs of sandy shale. One of these leaves (No. 2210) which is fairly complete is seen on Pl. 42. fig. 1. Its length is 13·5 cm. and its greatest breadth 10·3 cm. There is considerable doubt whether the actual apex is seen in this specimen. I am inclined to think that the rounded, entire, upper extremity is not the true apex, for the apical part of the leaf appears to have been broken off sharply, owing to the fact that the plane of the impression of the leaf did not

coincide with the plane of splitting of the ovoidal shale. Part of one margin, and of the base, is also wanting in this specimen. The complete leaf no doubt measured about 17 cm. in length, and about 15 cm. across at its greatest width, and must thus have been remarkable for its size.

As in the case of most of the other specimens, the flabellate lamina shows several fairly large, oval, or irregularly shaped elevations. These appear to be due to small twists or "knots" in the shale, and are simply imperfections in the preservation. In addition, a considerable number of small dark brown patches, oval in form or of irregular outline, are scattered over the lamina. These may be either attributed to fungal agency or explained as limited areas of decayed tissue, such as are met with in the fronds of many living ferns. They have been observed also in the case of many fossil leaves, e. g. *Glossopteris*. It is impossible to decide as to their origin at present, but there is no *primâ facie* evidence to lead one to suppose that they were in any way connected with the fructification of the plant.

The veins radiate from the suddenly contracted base with fairly frequent dichotomy, as is clearly seen in fig. 1 of Pl. 42, especially where the leaf broadens. The number of veins in the attenuated base exceeds a dozen, while, near the apex, the number is about 16 in 1 cm. breadth of the lamina, and they are 5 mm. or more distant from one another.

A well-preserved basal portion of a leaf (No. 2211) is seen in Pl. 43. fig. 6. It measures 10 cm. in length. The broad base is convex, which suggests that the leaf was probably sheathing at the base. The dichotomising nerves are very clearly seen. They are only about 8 in number at the extreme base, and here they are more distant from one another than in the more distal portion of the leaf.

An apical portion (No. 2212) is seen in Pl. 43. fig. 5. This specimen appears to show part of the true apex. The leaf was rounded and entire above, but slightly cleft or possibly split here and there. The cleft seen on the left appears to be a natural one, that on the right may be a tear, which did or did not exist in the living state. The apex measures 13 cm. across.

Another apical portion (No. 2214) is shown on Pl. 44. fig. 9. No doubt the upper limit here does not represent the true apex. Although the fragment measures 16 cm. across, there is no indication of any lobing or splitting. There are also several other similar impressions (Nos. 2083, 2213, and 2215), none of which show any clear signs of splitting at the apex.

All the leaves unfortunately are detached. Several impressions of axes (Nos. 2216–2218) are associated, but there is no evidence to show that they belonged to these leaves.

Distribution.—The Lower Carboniferous (or possibly Upper Devonian) rocks of Shenanditti River, on the west side of Red Indian Lake, Newfoundland.

The Affinities of Psygmophyllum majus.—The leaves described here appear to be very distinct from those of any other Palæozoic fossil known to me. Their nearest affinities appear to lie with members of the genus *Psygmophyllum*, a rare and little-known

assemblage of plants of Devonian, Carboniferous, and possibly of Permian age. The Newfoundland specimens appear to agree best with *Psygmophyllum Browni* (Dawson), see p. 398, from the ? Upper Devonian of Perry, Maine, U.S.A. Unfortunately, none of the leaves are attached. The basal portion above described suggests that the leaves may have sheathed the axis at the base, as is the case in *P. flabellatum* (L. & H.), the next species to be discussed. However, whether this was the case or not must remain in doubt for the present. In shape and size the leaf is specifically distinct from those of the two species above mentioned, though the type of nervation is the same in both. The discussion of the affinities of the genus may be more conveniently postponed until a later stage (p. 403).

3. PSYGMOPHYLLUM FLABELLATUM (Lindley & Hutton).

(Pl. 42. figs. 2, 3; Pl. 43. fig. 7; Pl. 44. figs. 8, 10, & 11.)

1831 or 1832. *Nœggerathia flabellata*, Lindley & Hutton, Fossil Flora, vol. i. p. 89, pls. 28, 29.

1849. *Nœggerathia flabellata*, Brongniart, Tableau Végét. foss. (Diction. Univer. Hist. Nat.) p. 65.

1870–72. *Psygmophyllum flabellatum*, Schimper, Traité Paléont. végét. vol. ii. p. 193.

1881. *Ginkgophyllum flabellatum*, Renault, Cours Bot. foss. vol. i. p. 65, pl. 7. fig. 5.

Diagnosis.—Leaves of medium size, up to 15 cm. or more in length, and to 11 cm. across at their greatest width, cuneate or subflabellate, spirally arranged on an axis, with long decurrent, fairly broad, sheathing bases. Margins slightly curved or nearly straight. Apex truncated, or ? slightly rounded, entire or ? fimbriated. Leaves undivided or ? more or less deeply cleft or split, or broadly lobed at apex. Nerves fine, numerous, flabellately arranged, with frequent dichotomy.

Type-specimens.—The types appear to be lost. As Lebour * has pointed out, they are not in the Hancock Museum, Newcastle-on-Tyne.

Description of the specimens.—So far as I am aware, the only specimens of this plant in this country are two or more in the Hancock Museum, Newcastle-on-Tyne, six in the Public Museum, Sunderland, and two in the British Museum (Nat. Hist.). I am indebted to the Councils of the two Institutions first mentioned for the loan of specimens for description. Those in the Sunderland Museum and the British Museum are the best preserved.

A re-examination of these specimens has led me to important conclusions with regard to the habit of this plant, which differ from those expressed by Lindley and Hutton in their 'Fossil Flora,' and by Schimper when establishing the genus. The former authors figure a detached leaf, and also another specimen which they regarded as a "portion of a compound leaf" consisting "of six or seven, or perhaps more, pairs of leaflets. The most perfect pinnæ are cuneate, taper very much to the base, have a dilated, undulated, slightly lobed, crenated extremity, and appear to have been flabelliform; others are narrower, and look like split portions of large pinnæ, which perhaps they are" †. They concluded that the frond belonged to a palm and not a fern, "from the veins not being

* Lebour ('78), p. 102.

† Lindley & Hutton ('31), pp. 89–90.

distinctly dichotomous, but gradually separating, imperceptibly, as the pinnæ widen from the base, without any obviously marked point of divergence." Schimper * also takes the view that the leaves are pinnatisect, with cuneiform segments.

There are specimens in all the three museums above mentioned, both of attached and detached leaves. They all occur on slabs of shale of a characteristic slate-colour; but there is, as a rule, very little contrast between the fossil and the rock on which the impression occurs, which tends to make any description of them difficult. Almost all the specimens have also undergone hard usage before the incrustations were made, many of the leaves being obviously torn and imperfect. The film of carbon is often badly cracked or even absent here and there (see Pl. 42. fig. 3). These facts, again, may prove a source of error in determination.

With regard to the detached leaves, probably the most perfect example we have is that in the British Museum † (text-fig. 1). It somewhat resembles that figured on pl. 29 of Lindley and Hutton's 'Fossil Flora.' It is 15·1 cm. long, and no doubt exceeded

Fig. 1.

The outline of a leaf of *Psygmophyllum flabellatum*, Lindl. & Hutt., No. 40,578 in the British Museum (Nat. Hist.), from Durham! One-half natural size.

11 cm. in breadth, part of the apex being wanting on the left-hand side. The elongated broad base is well seen, but it is highly probable that the upper extremity is not the true apex, which is either not present or is in part buried in the shale. There is a deep slit in the upper part of the leaf, on the left-hand side, which may be natural, though the fact is not beyond dispute. The irregular lobing at the extreme apex is no doubt due to bad preservation. So far as I am aware, there is no specimen known which shows the complete apex, and therefore we remain in doubt as to its characters, and as to whether

* Schimper ('70), p. 193.

† No. 40,578.

the leaf was really split or dissected above. The nerves can be seen here and there at the base. They are rather fine, but, despite Lindley and Hutton's conclusions, they undoubtedly dichotomise, as is also the case in many other specimens (Pl. 44. fig. 11).

I have also seen other, much smaller, detached leaves. There is one in the Sunderland Museum (Pl. 44. fig. 11) which is more flabellate in form. It apparently has a rounded, ? entire apex; but here, again, the higher portion of the leaf is probably not preserved. This specimen is 7 cm. long and 6 cm. across at its broadest part.

Another leaf, also in the Sunderland Museum, is shown in Pl. 44. fig. 10. It exhibits the nervation very clearly. Here it will be noticed that the leaf is cleft almost to the base into several segments. It is very difficult to say how far this was a natural feature. From a comparison with many other specimens I am inclined to think it was largely artificial. Evidence of the same splitting is seen in the case of the leaf shown on the left-hand side of fig. 8 of the same Plate. On the other hand, the apex may have been slightly incised or fimbriated, as Schimper * states, though I have not seen any absolutely definite evidence of the fact.

Of greater interest, perhaps, are the specimens which show several leaves attached to an axis †. I have studied several such examples, which appear to me to demonstrate beyond doubt, as Renault ‡ has already concluded, that we are dealing here with an axis bearing a number of spirally arranged leaves, and not with a pinnate frond. The leaves have long sheathing bases, which closely clasp the axis. The whole appearance of the leafy shoot is quite distinct from that of *Ginkgo*, and would lead one to believe that such fossils represent a herbaceous plant, and not a branch of an arborescent or shrubby genus. One of the clearest examples § I have seen is shown $\frac{3}{4}$ nat. size in Pl. 44. fig. 8. This specimen is in the Sunderland Museum. At least three leaves are seen here attached to the axis. A slightly enlarged portion of this shoot, showing the basal portions of three leaves, is reproduced on Pl. 42. fig. 3. The sheathing nature of the bases and the nervation of the leaves are clearly seen here. Between two of the leaves, fragments of what may have been the naked axis of a shoot is seen. In the photograph in Pl. 42. fig. 2, an axis is seen with the long sheathing portion of a leaf. The sheathing bases of two leaves are also clearly seen in Pl. 43. fig. 7.

In the case of one specimen in the Sunderland Museum, similar to Pl. 44. fig. 8, a number of rounded or irregularly oval, shallow depressions occur on the leaves. These contain no trace of any organic structure, and there is no evidence to lead me to believe that they mark the position of sori. Similar markings occur on certain fronds of *Glossopteris*, and are no doubt quite unconnected with the fructification of that plant.

Distribution.—So far as I am aware, this fossil is only known from England and

* Schimper ('70), p. 193.

† There is a further specimen in the British Museum (Nat. Hist.), Reg. No. 38,927, from "Jarrow Colliery, Durham"! [? Newcastle], which shows five leaves attached to an axis. The leaves are both very imperfect and much split into segments, and this specimen is inferior to those in the Sunderland Museum.

‡ Renault ('81), p. 65.

§ The type-specimen of Lindley and Hutton appears to have been a very confused, and a far from clear impression. It has been refigured by Renault ('81), p. 65, pl. 7. fig. 5, probably with less accuracy.

from the Newcastle Coalfield, where it has been obtained from the roof of the Bensham seam of the Middle Coal-Measures at the collieries at Jarrow and ? Hebburn-on-Tyne *. Kirkby and Duff †, in their paper on the geology of South Durham, record it as abundant from the Brockwell and other seams of the Etherley District. I have twice visited this part of the coalfield, and by the kindness of the Rev. W. J. Wingate, of Bishops Auckland, advertisements were posted at a large number of the pits in 1907, with a description and figure of the fossil, asking the miners to make a search for it. Despite these efforts, I have not been able to obtain a single specimen of the plant, and I doubt if it occurs at all in South Durham. Howse's ‡ conclusion that the specimens so labelled in the Duff collection, now in the Hancock Museum, Newcastle-on-Tyne, are only Cyclopteroid pinnules, adds weight to my suspicions.

4. A Revision of the Genus *Psygmophyllum*.

Besides the two representatives of the genus described above, several other species are known, and the opportunity may be taken here to revise the genus. Most of its members are very rare fossils which are not represented in any museum in this country, and the task of revision is therefore one of some difficulty.

The generic name *Psygmophyllum* was instituted by Schimper § for the reception of certain fossils, previously referred to the genus *Nœggerathia* of Sternberg, but which differed markedly from *N. foliosa*, Sternb., the type of that genus. Among these were the impressions now known by the names *Psygmophyllum flabellatum* (Lindl. & Hutt.), *P. cuneifolium* (Kutorga), and *P. expansum* (Brongn.). This generic term has since been widely adopted, though Renault || has more recently referred *P. flabellatum* (Lindl. & Hutt.) to the genus *Ginkgophyllum* of Saporta.

Schimper's ¶ definition of the genus is as follows:—"Leaves pinnatisect. Pinnæ erect, spreading, flabellate (hence name), strongly narrowed at the base, plicated longitudinally and flabellately, more or less deeply pinnatisect, or margin lobate or crenulate, nerves dichotomising several times, erect, radiating. Vernation of leaves vertically involute (*sec.* Eichwald)."

I should propose to emend the genus as follows:—Leaves large, flabellate or cuneiform, arranged spirally on an axis, sheathing at the base, which is fairly broad and not contracted to a slender petiole. Apex broad, rounded or truncated, entire or ? toothed, or broadly lobed or slightly divided into broad palmate lobes. Nerves radiating from the base with frequent dichotomy throughout the lamina, and not converging above.

Distribution in Time.—Upper Devonian to Permian.

* Howse ('88), p. 110. The specimens in the British Museum, and in the Sunderland and Newcastle Museums, were no doubt all derived from these localities, despite their labels.

† Kirby & Duff ('72), p. 178, and table opposite p. 180.

‡ Howse ('88), p. 110.

§ Schimper ('70), p. 192.

|| Renault ('81), p. 65.

¶ Schimper, *ibid.*

Enumeration of Species.

1. PSYGMOPHYLLUM FLABELLATUM (Lindl. & Hutt.), *ante* p. 394.
2. PSYGMOPHYLLUM MAJUS, Arber, *ante* p. 392.
3. PSYGMOPHYLLUM BROWNII (Dawson).

1862. ? *Cyclopteris Brownii*, Dawson, Quart. Journ. Geol. Soc. vol. xviii. p. 320, pl. 12. fig. 9.

1863. *Cyclopteris Brownii*, Dawson, Quart. Journ. Geol. Soc. vol. xix. p. 463, pl. 17. fig. 6.

1871. *Cyclopteris Brownii*, Dawson, Foss. Plants Devon. & Upper Silur. Form. Canada, pt. i. p. 46, pl. 15. fig. 172.

1882. ? *Cyclopteris (Platyphyllum) Brownii*, Dawson, *ibid.* pt. ii. p. 101, pl. 23. figs. 11–13.

Types.—The whereabouts of the type specimens is unknown to me, and this plant is not, so far as I am aware, represented in any museum in this country.

Diagnosis.—Leaf detached, large, flabellate, exceeding 10 cm. in length, and 7 cm. across at its widest part. Base broad, margins ? curved, apex rounded, ? lobed, ? deeply cleft. Veins comparatively few, three or more at base, with frequent dichotomy throughout the lamina, comparatively distant and stout.

Remarks.—Probably the earliest figure of this species is that given by Dawson in 1862, which relates to a very small portion, perhaps part of the apex of a leaf. This reference may be neglected. In the following year, the same author described a much more complete, detached leaf, which may be regarded as the true type. The leaf was, no doubt, imperfect, and probably the apical portion is not represented. The large slits shown in Dawson's figure may well be due to tearing, and may not have been a natural feature. This plant agrees somewhat closely with *Psygmophyllum majus*, Arber, but the nerves are apparently stronger and much more distant from one another. It is interesting to notice that a *Sphenophyllum* (the *Trichomanites filicula* of Dawson), very like *Sphenophyllum tenerrimum*, Stur (Pl. 44. fig. 12), occurs in the same locality, as is the case also in Newfoundland.

It appears to me to be very doubtful whether the fragmentary leaves assigned to this species by Dawson in 1882 (see above) are specifically determinable. At any rate, they do not appear to be obviously identical with the fossil here regarded as the type. Nor does it seem to me likely that Dawson's plant is identical with *Rhacophyllum truncatum*, Lesq., as Lesquereux * has concluded.

Distribution.—The ? Upper Devonian of Perry, Maine, U.S.A.; the Upper Devonian of Scaumenac Bay, Dalhousie, Canada, the latter a very doubtful record.

4. PSYGMOPHYLLUM OBTUSA (Lesquereux).

1858. *Nœggerathia obtusa*, Lesquereux, in Rogers, Geol. of Pennsyl. vol. ii. pt. ii. p. 854, pl. 1. fig. 11.

1879–80. *Archæopteris obtusa*, Lesquereux, 2nd Geol. Surv. Pennsyl. (Coal Flora) text (1880), vol. i. p. 301 P, Atlas (1879), pl. 49. figs. 6–7.

1882. ? *Cyclopteris obtusa*, Dawson, Foss. Plants Erian (Devon.) and Upper Silur. Form. Canada, pt. ii. p. 100, pl. 22. figs. 6–10.

Diagnosis.—Lesquereux's description (1880, see above) was as follows:—"Primary

* Lesquereux ('80), p. 312 P.

pinna very large; divisions alternate, open or curving back from the narrow naked rachis; pinnules large, half round at the apex, contracted and narrowed to the decurring base; nervation of the genus." I have not seen any specimens of this species, but, judging by the figures published by Lesquereux and Dawson, I should be inclined to substitute the following diagnosis:—Leaves of medium size, 3–5 cm. long and up to 4 cm. across, with long sheathing bases, arranged spirally on an axis, flabellate or obovate, ? undivided, probably rounded at the apex. Nervation delicate, nerves fairly close, with frequent dichotomies.

Type-specimens.—The whereabouts of the type-specimens is unknown to me.

Remarks.—The fig. 7 of pl. 49 of Lesquereux's 'Coral Flora' certainly suggests that we are here concerned with an axis more or less completely sheathed by the basal portions of leaves, as in *P. flabellatum* (Lindl. & Hutt.). The leaves appear to be somewhat similar to those of *P. Williamsoni*, Nath. It does not appear to be certain whether the notched apices shown in Lesquereux's figures may not be due to imperfections in the preservation.

The specimens figured by Dawson * in 1862 and 1871, from the Upper Carboniferous (formerly regarded as Devonian) rocks of St. John, New Brunswick, are, as Lesquereux has pointed out, a distinct species, and in my opinion should be referred to another genus.

Distribution.—*Pennsylvania, Carboniferous* (? *Lower*), Vespertine Red Shale, below Mauch Chunk; *Devonian*, Catskill Red Shale, Montrose; *Canada, Upper Devonian*, Scaumenac Bay, Dalhousie.

5. Psygmophyllum Williamsoni, Nathorst. (Pl. 42. fig. 4.)

1894. *Psygmophyllum Williamsoni*, Nathorst, K. Sven. Vetens.-Akad. Handl. vol. xxvi. no. 4. p. 15, pl. 2. figs. 1–2.

Diagnosis.—Frond of medium size (exceeding 10 cm. in length and 9 cm. in breadth), broadly flabellate, margins curved, gradually contracted at the base. Apex unknown. Nerves fairly fine, radiating from the base with occasional dichotomy.

Types.—In the Palæobotanical Museum of the Academy of Science, Stockholm.

Remarks.—This species is at present known from two fragments of detached leaves, which, through the kindness of my friend Professor Nathorst, I have had an opportunity of seeing in Stockholm. In neither case is the apex preserved, and it is impossible to say whether the leaf was divided distally. The feature which especially distinguishes this species is the fineness of the nerves, which, as Professor Nathorst has pointed out, are more delicate than those of *P. flabellatum* (Lindl. & Hutt.). The shape of the leaf agrees best with that of *P. Brownii* (Dawson) or *P. majus*, Arber.

It would seem possible that the fragment of a leaf named by Nathorst (see above, p. 13, pl. 1. fig. 12) *Cyclopteris* sp., from the Devonian of Klaas Billen Bay, Spitzbergen, may be also a portion of a leaf of *Psygmophyllum*, though it is too imperfect

* Dawson ('62), p. 319, pl. 15. fig. 33; ('71), p. 46, pl. 16. figs. 188, 188 *a*.

to be confidently assigned to this genus. Nathorst himself compares it with the American plant here described as *P. Browni* (Dawson).

Distribution.—Upper Devonian of Mimersthal, Spitzbergen.

6. PSYGMOPHYLLUM KIDSTONI, Seward.

1903. *Psygmophyllum Kidstoni*, Seward, Ann. S. African Mus. vol. iv. p. 93, pl. 12. fig. 1.
1908. *Psygmophyllum Kidstoni*, Seward, Quart. Journ. Geol. Soc. vol. lxiv. p. 123.

Type.—In the South African Museum, Cape Town.

Diagnosis.—"Vegetative shoots woody, bearing spirally disposed leaves. Leaves wedge-shaped, reaching a length of 13 cm., usually divided by a deep median sinus into two narrow wedge-shaped lobes, truncate distally, and tapering gradually to the proximal end of the lamina. Leaves sessile, attached to the axis by a narrow base. The lamina is traversed by numerous spreading and occasionally forked veins following a course parallel to the edge of the leaf. Organs of reproduction unknown." (Seward, 1903, p. 93.)

Remarks.—As Professor Seward remarks, his species closely resembles *P. flabellatum* (Lindl. & Hutt.). Only a few of the leaves of this specimen are, however, attached to the fairly stout axis, and these show no sign of the long, sheathing bases found in the English species. The preservation of the lower parts of many of the leaves is no doubt imperfect in the South African specimen, and therefore too great weight must not be placed on the apparent absence of this character. At any rate the leaves here appear to possess a much narrower base than in *P. flabellatum.* The bilobed nature of the leaf, in some cases split almost to the base, is another point of difference, for while the leaves of *P. flabellatum* are often *apparently* deeply split, it is not possible at present to decide how far this feature was natural and constant. Certainly many of the leaves (*cf.* text-fig. 1, p. 395) were not deeply divided.

Distribution.—The Permo-Carboniferous (Ecca beds) of Vereeniging, Transvaal, S. Africa, associated with the *Glossopteris* flora.

Species exclusa.

It will be remembered that Schimper when instituting the genus *Psygmophyllum*, in which *P. flabellatum* (Lindl. & Hutt.) was placed first, perhaps because it was the earliest-described species, also referred to his new genus two plants from the Permian of Russia, which have since been known as *P. expansum* (Brongn.) and *P. cuneifolium* (Kutorga). There are specimens of both these plants in the British Museum, where I have had an opportunity of examining them. The question whether these plants should still be retained in the genus *Psygmophyllum* is a very difficult one. After a comparison of the actual specimens in London, and of all the figures of these plants which have been published, I am inclined to exclude them (at least provisionally) on the grounds that they are best referred to a separate genus. They are no doubt related to *Psygmophyllum*, just as they are to *Rhipidopsis*, Schmalhausen, and very probably the three genera all belong to one family.

To illustrate the nature of my objections to the inclusion of the Russian Permian species in *Psygmophyllum*, I will briefly discuss the figures published of these two species.

Nœggerathia cuneifolia, Kutorga.—The original figure of Kutorga * suggests either that the fossil was a pinnate leaf, with a large terminal segment and long, decurrent, cuneiform, lateral segments, or that it represents an axis bearing a number of wedge-shaped leaves, each sheathing the axis at the base. On the former supposition, adopted by Kutorga, and confirmed by subsequent figures of this species, it is difficult to see any similarity between this plant and *Psygmophyllum flabellatum* (Lindl. & Hutt.). The specimen figured by Brongniart †, which is sometimes erroneously thought to be the type, is a fragment of a lobed cuneiform leaf, the attachment of which is not shown. Eichwald's ‡ specimen, which consists of a more highly compound leaf with narrow wedge-shaped segments, more widely separated, is also detached. Lastly, we have Schmalhausen's § figures, two of which resemble those already discussed, while the third (pl. 5. fig. 11) is probably more correctly referred to the genus *Baiera*. We may note therefore that none of the more recent figures afford as much information as Kutorga's type, and that these plants have apparently little in common with the species of *Psygmophyllum* described here.

Nœggerathia expansa, Brongniart.—Schmalhausen regards Kutorga's ‖ *Sphenopteris interrupte-pinnata* as the first described example of this plant. Even if this is the case, which, judging by the figure, appears to me to be very doubtful, it does not seem to be at all evident that Kutorga's plant has anything in common with *Psygmophyllum flabellatum* (Lindl. & Hutt.). The *Cyclopteris gigantea* of Kutorga ¶, described in 1844, is much like a *Psygmophyllum*. I am not, however, convinced that it is identical with the *Nœggerathia expansa* of Brongniart. Of Brongniart's ** figures of this fossil, it is very difficult to come to any conclusion concerning those on pl. B. figs. 4 *a*, 4 *b*. The four figures on plate E are best regarded as the types of this species. The leaves shown here have lobed or dissected margins, and are strongly plicated. The base seems to be fairly broad, but none of the leaves are attached to an axis.

Eichwald's †† chief figure of this species appears to be a restoration. The leaves as shown here are deeply divided, lobed, and plicated. There does not seem to be any clear evidence as to their mode of attachment. Either the whole represents a pinnate leaf, as Eichwald concluded, or we have here several leaves decurrent on an axis. Judging by the figure, the former view appears to be the more probable interpretation. Eichwald also figures some oval bodies, which he regards as buds of this plant, though the fact does not seem to be supported by direct evidence. Of Schmalhausen's ‡‡ figures assigned to this species, figs. 8 and 9 on plate 3 resemble *Psygmophyllum*, while fig. 10

* Kutorga ('38), p. 32, pl. 7. fig. 3.

† Brongniart ('45), p. 9, pl. A. fig. 3.

‡ Eichwald ('60), p. 256, pl. 13. fig. 16.

§ Schmalhausen ('87), p. 19, pl. 3. fig. 11, pl. 4. fig. 8, pl. 5. fig. 11.

‖ Kutorga ('38), p. 30, pl. 6. fig. 1.

¶ Kutorga ('44), p. 82, pl. 2. fig. 7.

** Brongniart ('45), p. 9, pl. B. figs. 4 *a*, 4 *b*, pl. E. figs. 1 *a*, 1 *b*, 1 *c*, 1 *d*.

†† Eichwald ('60), p. 257, pl. 13. fig. 17.

‡‡ Schmalhausen ('87), p. 18, pl. 3. figs. 8–10, pl. 4. figs. 1–7.

of the same plate and fig. 5 of plate 4 appear to be scarcely distinct from *Rhipidopsis*, Schmalh. The remaining figures of plate 4 are similar to the specimens figured by Brongniart. The leaves are lobed, divided, and strongly plicated.

I understand that my friend Dr. Zalessky, of the Russian Geological Survey, is about to redescribe the Permian species referred to above, and I will thus not suggest a further genus for their reception here. As Professor Zeiller * has said of *Psygmophyllum expansum*, so-called, it scarcely differs from *Rhipidopsis* except by the decurrence of the leaflets, generally united to one another for part of their length, and contracted little by little at the base to a common petiole. I may also point out that these remarks illustrate the existence of another difficulty, namely, whether it is more correct to regard the organ referred to above as a palmately divided leaf, as I should be inclined to describe it, or as a compound structure formed by the partial union of several leaves. But whatever may be the true nature of these fossils, they are interesting as showing a possible transition from *Psygmophyllum* proper, with its undivided leaves sheathing at the base, to the *Rhipidopsis* type, where the leaves are very deeply divided into unequal segments mounted on a thin common stalk.

Næggerathia ctenoides, Göppert †.—This fossil was included by Schimper in his genus *Psygmophyllum*. Judging by the figure, however, it appears to be a pinnatifid leaf, having little or nothing in common with *P. flabellatum* (Lindl. & Hutt.).

Psygmophyllum angustilobum, Schenk ‡.—Zeiller § has already pointed out that this fossil from China is no doubt a species of *Eremopteris*.

Næggerathia flabellata of Geinitz (*non* Lindl. & Hutt.).—There does not appear to me to be any evidence that the small fragment of a leaf referred to Lindley and Hutton's species by Geinitz ‖ is a representative of this genus or species. It is more probably a leaf of *Cordaites*.

Ginkgophyllum Grasseti, Sap.—The fossil from the Permian rocks of Lodève, Hérault, described by Saporta ¶ (1879) as *Ginkgophyllum Grasseti*, is no doubt closely related to *Psygmophyllum*. The much divided wedge- or fan-shaped leaves with long sheathing bases, arranged spirally on an axis, recall those of *P. flabellatum* (Lindl. & Hutt.), especially in habit. I am, however, inclined to exclude for the present from the genus *Psygmophyllum* those plants in which, as in *Ginkgophyllum Grasseti*, the wedge-shaped leaves are deeply divided into long, narrow segments. The genus *Ginkgophyllum* may perhaps be retained for such leaves, and to include Saporta's species, though it is somewhat unfortunate that it obviously cannot be made to include also the Mesozoic leaf-impressions, which more closely resemble those of the modern *Ginkgo*.

Ginkgophyllum minus, Sandb.—The description given by Sandberger ** of *Ginkgophyllum minus*, from the "Schieferthone von Schramberg" in Germany, would seem to agree very well with that of members of the genus *Psygmophyllum*. The leaves are

* Zeiller ('00), p. 251.

† Göppert ('64), p. 159, pl. 40. fig. 1.

‡ Schenk ('83), p. 221, pl. 43. figs. 22–24.

§ Zeiller ('01), p. 461.

‖ Geinitz ('54), p. 63, pl. 12. fig. 9.

¶ Saporta ('79), p. 186, fig. 15 (5); ('84), p. 228, pl. 152. fig. 2. See also Schimper & Schenk ('91), p. 252, fig. 179; Zeiller ('00), p. 252, fig. 179.

** Sandberger ('91), p. 101.

alternate, elongately cuneiform, and attenuated or decurrent at the base. No figure has, however, been published of this plant, which Sterzel * has more recently referred to the genus *Dicranophyllum*. This is probably the correct position to which the species should be assigned, for Sandberger describes the leaves as "supra mediam partem bipartita et ad fines pluries furcata."

Psygmophyllum Hollandi, Seward.—In 1905, Prof. Seward † described a very fragmentary leaf from the Permo-Carboniferous of Kashmir as ? *Psygmophyllum* sp. As the author then remarked, it is very difficult to decide as to the genus to which such a fragmentary fossil rightly belongs. Judging by his figure, however, I am not inclined to include it in the genus *Psygmophyllum*, as here emended, but to compare it with *Rhipidopsis* or some allied genus. The same author ‡ in 1907 figured some leaves, deeply divided into long narrow segments, under the name *P. Hollandi*, sp. nov. These specimens, which were also derived from Kashmir, he regarded as probably specifically identical with that mentioned above. They appear to me to agree more closely with *Ginkgophyllum* or some similar genus.

Psygmophyllum Delvali, Camb. & Renier §.—Through the kindness of my friend Professor Renier, I have had an opportunity of seeing at Liège the type-specimen of the large leaf, described by him and M. Cambier as *P. Delvali*. It appears to me to be a large leaf of *Cordaites*, though in the broad rounded apex it certainly resembles *Psygmophyllum*.

Cf. Nœggerathia flabellata, Carpentier (*non* Lindl. & Hutt.).—Since these remarks were written, I have received, by the kindness of the author, a copy of an interesting paper by Abbé Carpentier on some Pteridospermous fructifications. Certain fossils ‖ are there compared with *P. flabellatum*, Lindl. & Hutt., but, so far as I can judge from the figures given of them, they are very much smaller and quite unlike the leaves of that plant ¶.

5. A Discussion of the Affinities of *Psygmophyllum*.

The six species here referred to the genus *Psygmophyllum* all appear to have characters in common, though it must be borne in mind that we still know very little of these ancient plants. It may therefore eventually prove that fossils of dissimilar affinity have

* Sterzel ('07), p. 820.

† Seward & Woodward ('05), p. 6, pl. 9. fig. 3.

‡ Seward ('07), p. 59, pl. 13. figs. 5–6.

§ Cambier & Renier ('10), p. 23, pl. 6. fig. 1; Renier ('10), p. 21, pl. 118.

‖ Carpentier ('11), p. 15, pl. 15. fig. 7, pl. 16. fig. 4.

¶ Since this paper left my hands, Professor Seward has published a memoir on the "Lower Gondwana Plants from the Golabgarh Pass, Kashmir" (Mem. Geol. Surv. India = Pal. Indica, n. s. vol. iv. no. 3, p. 6, pl. iii., 1912). In this paper a very interesting Permo-Carboniferous plant is described under the name *Psygmophyllum Haydeni*, sp. nov. The leaves are "deeply dissected into six or more obcuneate segments," but "there is no well-defined petiole as distinct from the flat leaf-segments." Though, as the author points out, there are certainly points of resemblance between this plant and species of *Psygmophyllum*, I should, however, be inclined to refer it to some other genus, perhaps *Ginkgophyllum*, Sap., or *Rhipidopsis*, Schmalh., on the grounds that in *Psygmophyllum*, as here restricted, the leaf does not appear to be divided to, or nearly to, the base into a number of segments.—E. A. N. A., *April 16th*, 1912.

been here included under the same generic name, and perhaps some of the species here excluded may in future be shown to be true members of the genus.

As regards the general habit, in the case of three species, the leaves are known attached to the stem. In two of these, *P. flabellatum* (Lindl. & Hutt.) and *P. obtusa* (Lesq.), the appearance of the shoots, closely set with long, decurrent leaf-bases, suggests that we are dealing here with herbaceous, and not arborescent, plants. *P. Kidstoni*, Sew., however, does not appear to support this view. The habit of these three plants certainly is unlike anything known among the Ginkgoales, Coniferales, Ferns, or Cycadophyta.

Turning next to the leaves, I have proposed in emending the genus, somewhat drastically perhaps, to retain only those species in which the leaves are flabellate or cuneiform, yet not deeply divided or split into narrow segments, and attached spirally to an axis by long decurrent leaf-bases. These leaves correspond to such species as *Ginkgo digitata* (Brongn.) among the *Mesozoic Ginkgoales*, while *Ginkgophyllum*, Sap.*, corresponds to species of *Baiera*, where the leaf is split nearly to the base into narrow segments, which sometimes fork. The genera *Dicranophyllum*, Grand'Eury, and *Trichopitys*, Sap., may perhaps represent a third type with very narrow forked segments, corresponding to *Czekanowskia*, Heer.

The leaves of the six species described here, especially those which are flabellate in form, appear to agree better with those of *Ginkgo biloba* than with any other plant. Yet opinions have varied very widely on this point. Lindley and Hutton † regarded *P. flabellatum* as a Palm. Renault ‡ concluded that it is possible that the anatomical structure will one day show that *Psygmophyllum* is a type intermediate between the Ginkgoales and Cycadales. On the other hand, Dawson regarded *P. Browni*, and Lesquereux *P. obtusa*, as Ferns. Nathorst included *P. Williamsoni* under the non-committal title ? Gymnospermæ. Seward referred *P. Kidstoni* with considerable doubt to the Ginkgoales—a view also expressed by other authorities in recent accounts of the genus, and formerly also by Saporta. Schimper §, however, included the genus in the Cycads.

While there may be a certain resemblance in form between the leaves of *Psygmophyllum* and *Ginkgo*, especially in regard to the characters of the apex, I am convinced that the similarity is purely superficial. The long sheathing bases of the leaves of *Psygmophyllum* are quite unlike the slender petioles of *Ginkgo*; and further it has been shown here that, in at least two species of the former genus, the leaves were borne in a totally different fashion to those of the living plant. There is also no exact correspondence as regards the nervation.

Unfortunately, in no case have we any evidence of the fructification of any member of the genus, and until this has been discovered it is impossible to come to any definite conclusion as to the affinities of these plants. I am, however, inclined to think that they are possibly related to some or all of the following *Palæozoic* genera :—*Ginkgophyllum*,

* Saporta ('75), p. 1018. It is somewhat unfortunate that the name *Ginkgophyllum* was applied by Saporta to leaves which, both in their form and mode of attachment, are very different from those of *Ginkgo biloba*. This term might otherwise have served as a useful name for Mesozoic leaves, such as *Ginkgo digitata* (Brongn.) which closely resemble those of the living plant, but which probably should not be included in the living genus. Perhaps some such term as *Euginkgophyllum* might be applied to these Mesozoic impressions.

† Lindley & Hutton ('31), p. 89. ‡ Renault ('81), p. 65. § Schimper ('70), p. 192.

Sap., *Dicranophyllum*, Grand'Eury, *Trichopitys*, Sap., *Rhipidopsis*, Schmalh., and perhaps *Næggerathia foliosa*, Sternb. These genera begin to appear in Westphalian times (*Næggerathia*), but none of them are so ancient as *Psygmophyllum*. They increase in number and variety as we pass up through the Stephanian into the Permian. In the case of *Dicranophyllum*, *Trichopitys*, and *Næggerathia foliosa*, something is known of their fructifications in the form of impressions. I do not propose to discuss these here. They will be found described in most of the text-books, and I have nothing to add beyond the conclusion that they do not appear to me to agree with those of any known mesophytic or neophytic group.

I regard these genera as belonging to a distinct group of Palæozoic plants, for which I propose the name Palæophyllales*. It is for the future to prove or disprove the conception that this group may have been the ancestors of the Ginkgoales. At present it seems a possibility, but one which is founded on nothing more than a certain correspondence, by no means close, as regards the leaf form. Until we have definite evidence of the fructifications of these plants, it seems to me better to refer to them under the perfectly non-committal name of Palæophyllales, than to use any such term as Protoginkgoales, which implies a relationship, of which there is all too little evidence at the present time.

Whatever may have been the affinities of the Palæophyllales, there is no doubt that, like the Primofilices, Coniferales, and Cycadophyta, they were not a dominant, but a subsidiary element in the flora of the Upper Palæozoic period. They represent either the first incomings of a new race, or, as appears less likely, the last lingering stage of an ancient group. The fact that the genera appear to become more abundant in the Stephanian and Permian favours the former conclusion; and the group, although subsidiary in variety and abundance to many others, may have been none the less successful, and may have given rise to some Mesophytic race, perhaps the Ginkgoales, which played a still more important rôle in a later flora.

6. Bibliography.

Arber, E. A. N. ('10).—A Note on some Fossil Plants from Newfoundland. Proc. Cambr. Phil. Soc. vol. xv. pt. v. p. 390, 1910.

Brongniart, A. ('45).—In Murchison, R. I., Verneuil, É. de, and Keyserling, A. de, 'Géologie de la Russie d'Europe,' etc., vol. ii. Paléont. p. 5, 1845.

Cambier, R., and Renier, A. ('10).—*Psygmophyllum Delvali*, n. sp., du Terrain houiller de Charleroi. Ann. Soc. Géol. Belgique, vol. ii. Mém. (4°) p. 23, 1910.

Carpentier, A. ('11).—Sur quelques fructifications et inflorescences du Westphalien du Nord de la France. Rev. Génér. Bot. vol. xxiii. p. 1, 1911.

Dawson, J. W. ('62).—On the Flora of the Devonian Period in North-eastern America. Quart. Journ. Geol. Soc. vol. xviii. p. 296, 1862.

—— ('71).—The Fossil Plants of the Devonian and Upper Silurian Formations of Canada. Geol. Surv. Canada, 1871.

Eichwald, E. ('60).—Lethæa Rossica, ou Paléontologie de la Russie. Stuttgart. Vol. i. 1860.

* παλαιὸς = ancient; φύλλον = a leaf.

GEINITZ, H. B. ('54).—Darstellung der Flora des Hainichen-Ebersdorfer und des Floehaer Kohlenbassins. Leipzig, 1854.

GÖPPERT, H. R. ('64).—Die fossile Flora der Permischen Formation. Palæontograph. vol. xii. 1864–5

HOWSE, R. ('88).—A Catalogue of Fossil Plants from the Hutton Collection, etc. Newcastle-on-Tyne, 1888.

KIRKBY, J. W., and DUFF, J. ('72).—Notes on the Geology of Part of South Durham. Nat. Hist. Trans. Northumberland and Durham, vol. iv. p. 150, 1872.

LEBOUR, G. A. ('78).—Catalogue of the Hutton Collection of Fossil Plants, etc. Newcastle-on-Tyne, 1878.

LESQUEREUX, L. ('80).—Description of the Coal Flora of the Carboniferous Formation in Pennsylvania. (2nd Geol. Surv. Pennsylv.) Vol. i. Text, 1880; Plates, 1879. Harrisburg.

LINDLEY, J., and HUTTON, W. ('31).—The Fossil Flora of Great Britain, etc. Vol. i. London, 1831-3.

KUTORGA, S. ('38).—Beitrag zur Kenntniss der organischen Ueberreste des Kupfersandsteins am westlichen Abhange des Urals. Mineralog. Gesellsch. St. Petersburg, 1838.

—— ('44).—Zweiter Beitrag zur Palæontologie Russlands. Verhandl. Miner. Gesellsch. St. Petersburg, p. 62, 1844.

RENAULT, B. ('81).—Cours de Botanique fossile, fait au Muséum d'Histoire naturelle. Prem. Ann. (vol. i.). Paris, 1881.

RENIER, A. ('10).—Documents pour l'étude de la Paléontologie du terrain houiller. Liège, 1910.

SANDBERGER, F. v. ('91).—Ueber Steinkohlenformation und Rothliegendes im Schwarzwald und deren Floren. Jahrb. k.-k. Geol. Reichsanst. Wien, vol. xl. p. 77 (1890), 1891.

SAPORTA, L. C. J. G. DE ('75).—Sur la découverte de deux types nouveaux de Conifères dans les Schistes permiens de Lodève (Hérault). Compt. Rend. Acad. Sci. vol. lxxx. p. 1017, 1875.

—— ('79).—Le Monde des plantes avant l'apparition de l'homme. Paris, 1879.

—— ('84).—Plantes Jurassiques: vol. iii. Conifères ou Aciculariées. Paléontol. franç. sér. 2, Végétaux. Paris, 1884.

SCHENK, A. ('83).—In Richthofen's 'China,' vol. iv. Pflanzen aus der Steinkohlen-Formation, p. 209, 1883.

SCHIMPER, W. P. ('70).—Traité de Paléontologie végétale. Vol. ii. Paris, 1870–72.

SCHIMPER, W. P., and SCHENK, A. ('91).—In Zittel, Traité de Paléontologie. Part ii. Paléophytologie. Transl. by Barrois. Paris, Munich, & Leipzic, 1891.

SCHMALHAUSEN, J. ('87). Die Pflanzenreste der Artinskischen u. Permischen Ablagerungen im Osten des Europäischen Russlands. Mém. Com. Géolog. St. Pétersbourg, vol. ii. no. 4, 1887.

SEWARD, A. C. ('07).—Permo-Carboniferous Plants from Kashmir. Rec. Geol. Surv. India, vol. xxxvi. p. 57, 1907.

SEWARD, A. C., and WOODWARD, A. S. ('05).—Permo-Carboniferous Plants and Vertebrates from Kashmir. Mem. Geol. Surv. India = Pal. Indica, n. s. vol. ii. Mem. 2, 1905.

STERZEL, J. T. ('07).—Die Karbon- und Rothliegendenfloren im Grossherzogtum Baden. Mitt. badisch. geol. Landesanst. vol. v. p. 345, 1907.

ZEILLER, R. ('00).—Éléments de Paléobotanique. Paris, 1900.

—— ('01).—Note sur la Flore houillère du Chansi. Ann. des Mines, sér. 9, vol. xix. p. 431, 1901.

7. EXPLANATION OF THE PLATES.

(The negatives of figs. 2, 3, 7, 8, and 10 are by the Author, those of figs. 1, 5, 6, 9, 11, and 12 are by Mr. Tams. All the prints are by Mr. Tams, Cambridge, except fig. 4, which was kindly supplied by Prof. Nathorst.)

Plate 42.

Fig. 1. *Psygmophyllum majus*, sp. nov., from Newfoundland. A nearly complete leaf. No. 2210 in the Carbon. Plant Coll. Sedg. Mus. Camb. Slightly enlarged.

2. *Psygmophyllum flabellatum* (Lindl. & Hutt.). An axis showing the long, decurrent, sheathing base of a leaf. A specimen from Newcastle in the Sunderland Museum. $\frac{3}{4}$ nat. size.

3. *Psygmophyllum flabellatum* (Lindl. & Hutt.). An enlarged portion of the shoot seen in fig. 8, showing the bases of three leaves attached to the axis, and the nervation. From a specimen in the Sunderland Museum. Very slightly enlarged.

4. *Psygmophyllum Williamsoni*, Nathorst. The type-specimen in the Palæobotanical Museum, Stockholm. Nat. size.

Plate 43.

Fig. 5. *Psygmophyllum majus*, sp. nov. The apical portion of a leaf. No. 2212 in Carb. Plant Coll. Sedg. Mus. Camb. Slightly enlarged.

6. *Psygmophyllum majus*, sp. nov. The basal portion of a leaf, showing the nervation clearly. No. 2211 in Carb. Plant Coll. Sedg. Mus. Camb. $\times \frac{5}{4}$.

7. *Psygmophyllum flabellatum* (Lindl. & Hutt.). Showing the long, decurrent, sheathing bases of two leaves. From a specimen in the Sunderland Museum. Nat. size.

Plate 44.

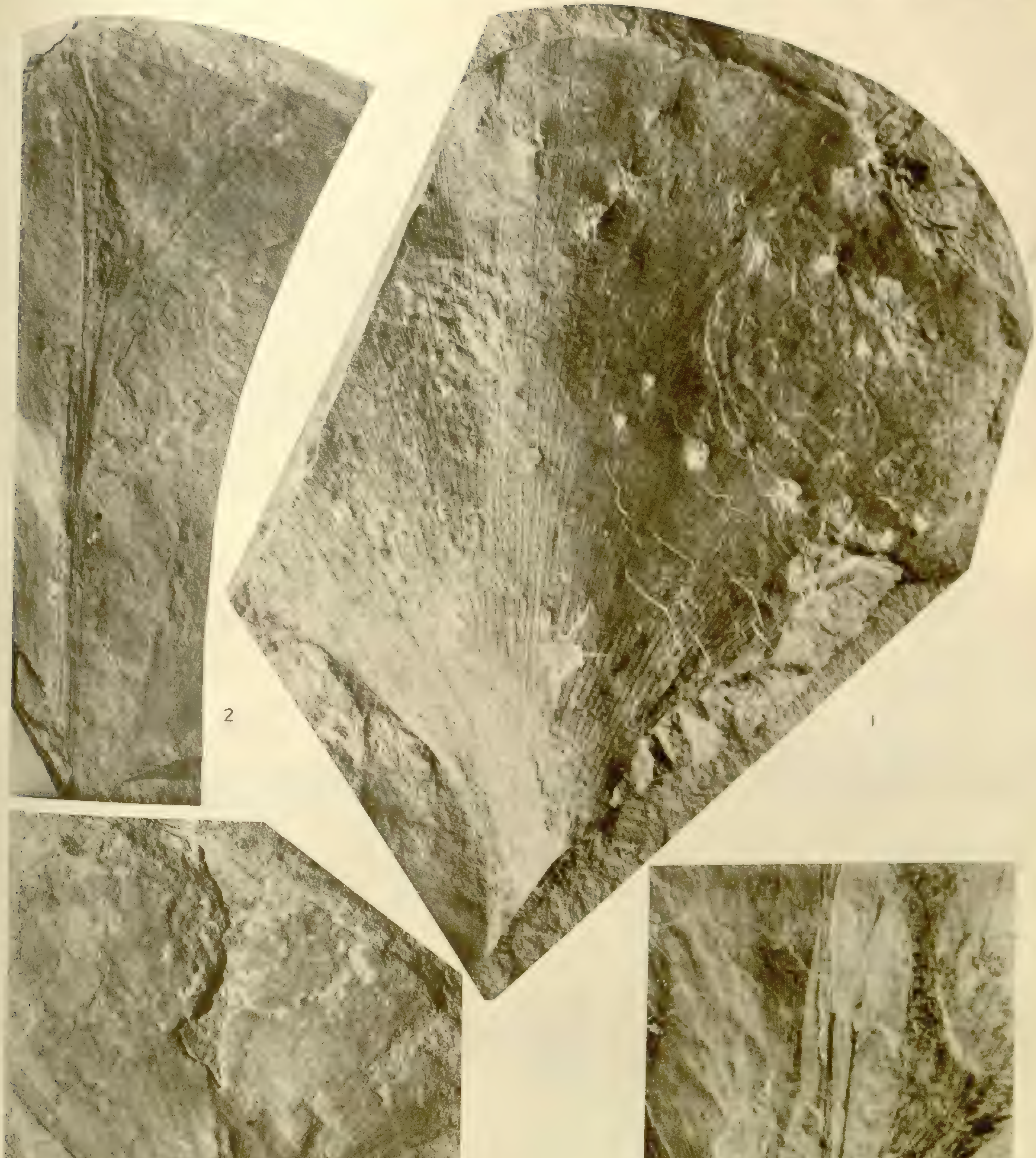
Fig. 8. *Psygmophyllum flabellatum* (Lindl. & Hutt.). A shoot showing portions of four leaves attached to a stem. From a specimen in the Sunderland Museum. $\frac{3}{4}$ nat. size.

9. *Psygmophyllum majus*, sp. nov. Portion of a leaf. No. 2214 in Carb. Plant Coll. Sedg. Mus. Camb. Slightly reduced.

10. *Psygmophyllum flabellatum* (Lindl. & Hutt.). A single leaf from a specimen in the Sunderland Museum. Slightly reduced.

11. *Psygmophyllum flabellatum* (Lindl. & Hutt.). A photograph of a drawing of a single leaf in the Sunderland Museum. Nat. size.

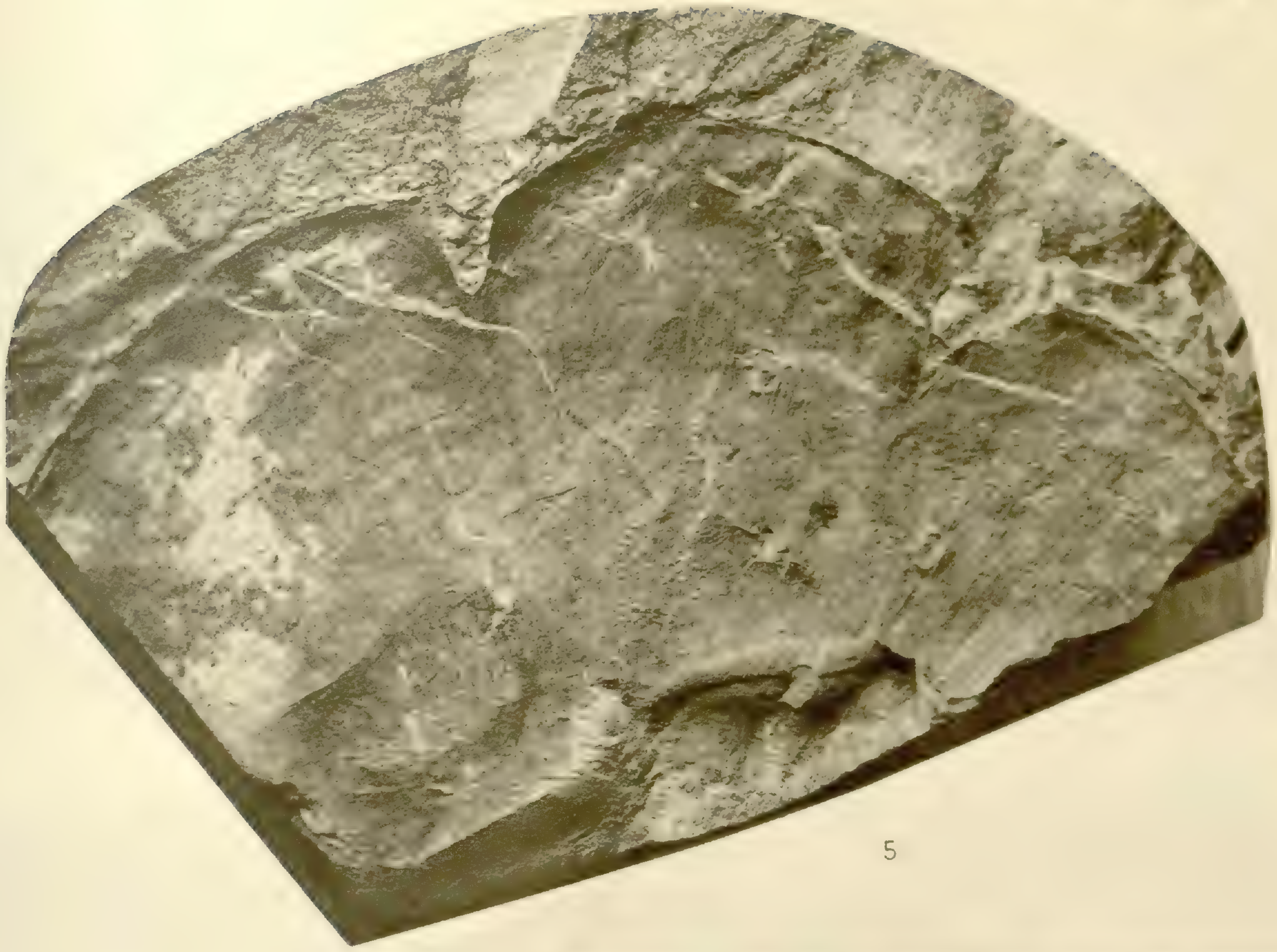
12. *Sphenophyllum tenerrimum*, Stur, associated with the specimen of *Psygmophyllum majus*, sp. nov., shown in fig. 1. No. 2210 Carb. Plant Coll. Sedg. Mus. Camb. $\times 2 \cdot 5$.



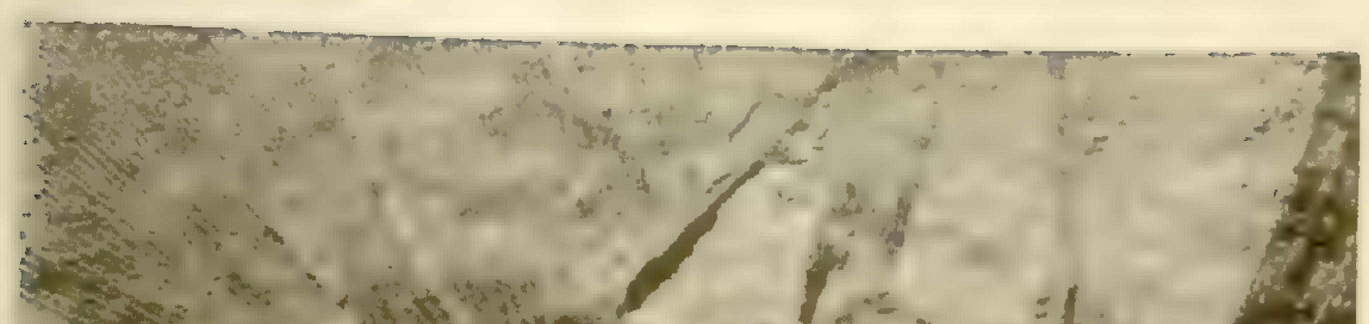
E A N A & W. Tams Photo.

London [illegible]

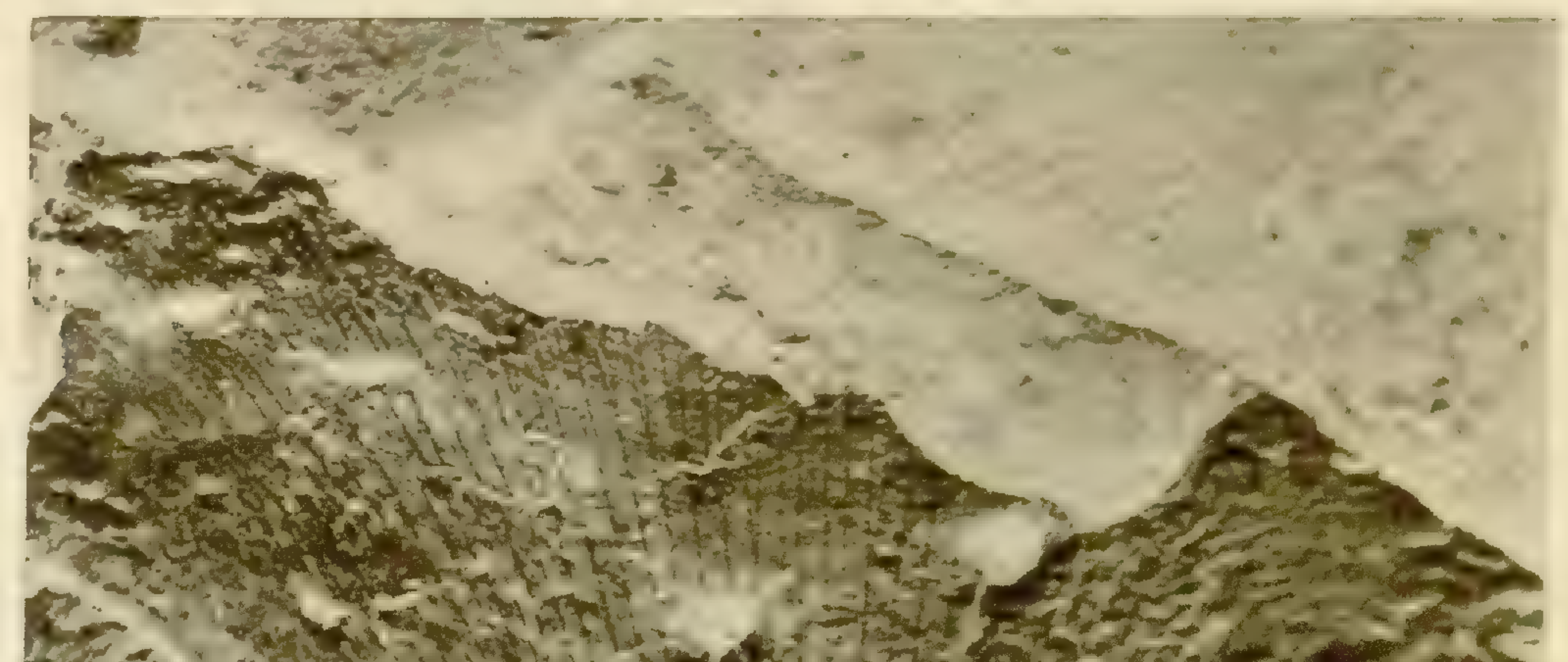
PSYGMOPHYLLUM MAJUS, P. FLABELLATUM & P WILLIAMSONI



5



7



6

A.N.A. & W. Tams. Photo.

London Stereoscopic Co. imp.

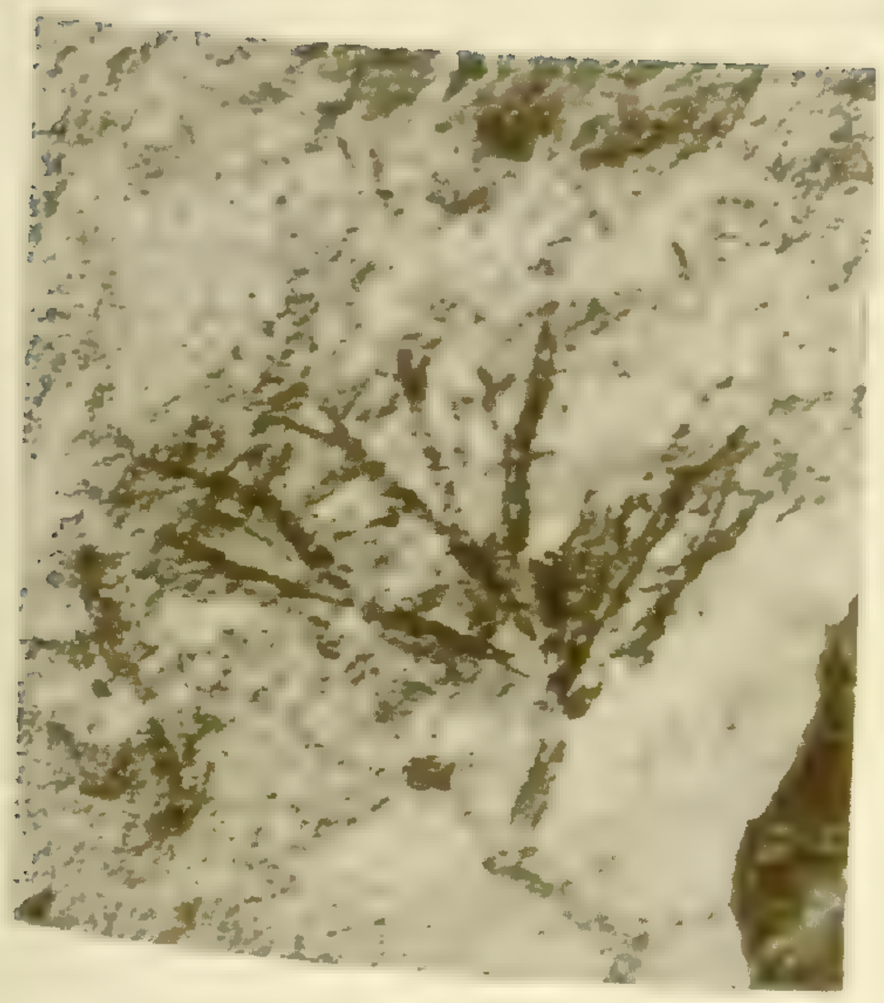
PSYGMOPHYLLUM MAJUS, & P. FLABELLATUM

10

8

11

9



12

E.A.N.A. & W. Tams Photo

PSYGMOPHYLLUM FLABELLATUM P. MAJUS, & SPHENOPHYLLUM TENERRIMUM

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s.* to the public, and 6*s.* to Fellows; to Vols. 26–30, 4*s.* to the public, and 3*s.* to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

SECOND SERIES.—BOTANY.

Volume.	Part	When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
I.	Parts I.–IX. (complete).	1875–80	8	1	0	6	1	0
II.	Parts I.–XVI. (complete).	1881–88	6	16	10	5	2	9
III.	Part I.	1888	3	12	0	2	14	0
	Part II.	1891	0	5	0	0	3	9
	Part III.	1891	0	7	0	0	5	0
	Part IV.	1891	0	6	0	0	4	6
	Part V.	1891	0	6	0	0	4	6
	Part VI.	1891	0	3	6	0	2	8
	Part VII.	1892	0	6	0	0	4	6
	Part VIII.	1893	0	6	0	0	4	6
	Part IX.	1893	1	8	0	1	1	0
	Part X.	1894	0	10	0	0	7	6
	Part XI.	1894	0	3	4	0	2	6
IV.	Part I.	1894	1	0	0	0	15	0
	Part II.	1894	2	0	0	1	10	0
	Part III.	1895	2	10	0	1	17	0
	Part IV.	1895	0	3	4	0	2	6
V.	Part I.	1895	0	9	0	0	6	9
	Part II.	1895	0	12	0	0	9	0
	Part III.	1896	0	6	0	0	4	6
	Part IV.	1896	1	0	0	0	15	0
	Part V.	1896	0	14	0	0	10	6
	Part VI.	1896	0	4	0	0	3	0
	Part VII.	1897	0	4	0	0	3	0
	Part VIII.	1897	0	6	0	0	4	6
	Part IX.	1899	0	12	0	0	9	0
	Part X.	1899	0	6	0	0	4	6
	Part XI.	1899	0	7	0	0	5	0
	Part XII.	1899	0	12	0	0	9	0
	Part XIII.	1900	0	1	6	0	1	2
	Part XIV.	1900	0	3	0	0	2	3
	Part XV.	1901	0	6	0	0	4	6

SECOND SERIES.—BOTANY (*continued*).

Volume.	Part	When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
VI.	Part I.	1901	1	10	0	1	2	6
	Part II.	1901	0	6	0	0	4	6
	Part III.	1902	0	18	0	0	13	6
	Part IV.	1903	0	8	0	0	6	0
	Part V.	1903	0	8	0	0	6	0
	Part VI.	1903	0	12	0	0	9	0
	Part VII.	1904	0	12	0	0	9	0
	Part VIII.	1904	0	12	0	0	9	0
	Part IX.	1904	0	7	0	0	5	3
	Part X.	1904	0	14	0	0	10	6
	Part XI.	1905	0	4	0	0	3	0
VII.	Part I.	1904	0	5	0	0	3	9
	Part II.	1905	0	6	0	0	4	6
	Part III.	1906	0	3	0	0	2	3
	Part IV.	1906	0	7	0	0	5	3
	Part V.	1907	0	10	0	0	7	6
	Part VI.	1907	0	4	0	0	3	0
	Part VII.	1907	0	6	0	0	4	6
	Part VIII.	1908	0	5	0	0	3	9
	Part IX.	1908	0	2	6	0	2	0
	Part X.	1908	0	7	0	0	5	3
	Part XI.	1909	0	4	0	0	3	0
	Part XII.	1909	0	12	0	0	9	0
	Part XIII.	1909	0	5	0	0	3	9
	Part XIV.	1909	0	6	0	0	4	6
	Part XV.	1910	0	6	0	0	4	6
	Part XVI.	1912	0	3	0	0	2	3
	Part XVII.	1912	0	8	0	0	6	0
	Part XVIII.	1912	0	5	0	0	3	9

2nd Ser. BOTANY.]

[VOL. VII. PART 19.

THE TRANSACTIONS OF THE LINNEAN SOCIETY OF LONDON.

ON THE FERNS OF THE SEYCHELLES AND THE ALDABRA GROUP.

BY

CARL CHRISTENSEN, M.Sc. (Copenhagen).

(*Communicated by* Prof. J. STANLEY GARDINER, M.A., F.R.S., F.L.S.)

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

November 1912.

XIX. *On the Ferns of the Seychelles and the Aldabra Group.* By CARL CHRISTENSEN, *M.Sc.* (*Copenhagen*). (*Communicated by* Prof. J. STANLEY GARDINER, *M.A., F.R.S., F.L.S.*)

(Plate 45.)

Read 6th June, 1912.

ON the suggestion of Dr. O. Stapf, Keeper of the Herbarium and Library, Royal Botanic Gardens, Kew, I undertook the determination of a collection of ferns made in the Seychelles by Professor J. Stanley Gardiner during the 'Sealark' Expedition in 1908, and the preparation of a complete list of the ferns of the Seychelles. It is true, the islands are not a *terra nova* for pteridography; nevertheless a revision of the fern-flora of the islands was thought desirable so as to bring it into line with modern ideas of pteridography.

The ferns of the Seychelles have been dealt with twice by J. G. Baker*, and later on by M. Kuhn †, who published a list of the ferns occurring in the islands. Whilst Baker knew 74 species of true ferns indigenous in the island, Kuhn enumerated 76 species, and my list includes 78 species.

It was an easy task to name the specimens in accordance with Baker's treatment, but as my ideas of the delimitation of not a few species differ essentially from those of Baker, who takes the species in a much broader sense, I examined the material critically and compared it with specimens which the authorities of Kew kindly forwarded to me for that purpose. For this my best thanks are due to Sir David Prain and Dr. Stapf. As will be seen, I do not agree with all of Baker's determinations, and therefore my list differs in certain points from his. My nomenclature too is, of course, very different from his. With few exceptions, I follow the nomenclature of my 'Index Filicum,' which is quoted under each species. In that work the essential synonyms and references will also be found, wherefore it is unnecessary to repeat them here.

So far as is known, the Seychelles are inhabited by 78 species of ferns, all but one (*Ceropteris calomelanos*, which probably is introduced) indigenous in the islands. All these species were collected in the higher islands, Mahé and Silhouette; three or four were also found in Bird Island and Long Island. No fern is known from the other islands (Praslin, La Digue, and Curieuse). Prof. Gardiner has added four species to the fern-flora of the islands.

* J. G. Baker: "On the Seychelles Fern-Flora," in Trans. R. Irish Acad. vol. xxv. (1875), pp. 509–518, tabb. 28–31; 'Flora of Mauritius and the Seychelles' (1877).

† M. Kuhn: Cryptogamæ vasculares, in 'Botanik von Ost-Afrika' in Von der Decken's Reisen, vol. iii. part 1 (1879), pp. 68–69.

The composition of the fern-flora of the Seychelles is of some interest, because the group is situated so far east from the African continent. The following table shows the

Species of Western Distribution.			
American species extending eastwards to tropical Asia: 4.	American species extending eastwards to the Seychelles: 5.	Species confined to Africa and the South-eastern African islands: 10.	Species confined to the South-eastern African islands: 6.
Hymenophyllum polyanthos. *H. ciliatum.* *Elaphoglossum petiolatum.* *E. spathulatum.*	*Polypodium serrulatum.* *P. cultratum.* *Elaphoglossum martinicense.* *E. latifolium.* *Ophioglossum palmatum.*	*Trichomanes erosum.* *Oleandra articulata.* *Davallia chærophylloides.* *Stenochlæna tenuifolia.* *Pellæa Doniana.* *P. viridis.* *Pteris atrovirens.* *Adiantum rhizophorum.* *Lonchitis pubescens.* *Vittaria isoetifolia.*	*Hymenophyllum hygrometricum.* *Dryopteris strigosa.* *D. mauritiana.* *Aspidium pleiotomum.* *Diplazium sechellarum.* *Monogramma graminea.*

Species endemic in the Seychelles: 12.	Species of Eastern Distribution.		Cosmopolitan Species: 11.
	Species extending from tropical Africa to Polynesia: 18.	Polynesian-Asiatic species reaching westwards to the South-eastern African islands, not in continental Africa: 10.	
Cyathea sechellarum. *Dryopteris Hornei.* *D. Wardii.* *Leptochilus bipinnatifidus.* *Lindsaya Kirkii.* *L. Hornei.* *Asplenium complanatum.* *Stenochlæna Pervillei.* *Pteris Barklyæ.* *Polypodium Pervillei.* *P. albobrunneum.* *Elaphoglossum Hornei.*	*Microlepia speluncæ.* *Schizoloma ensifolium.* *Asplenium nidus.* *A. unilaterale.* *Adiantum caudatum.* *Actiniopteris australis.* *Pteris tripartita.* *Vittaria elongata.* *V. scolopendrina.* *Hymenolepis spicata.* *Polypodium punctatum.* *P. phymatodes.* *Cyclophorus spissus.* *Platycerium bifurcatum.* *Ceratopteris thalictroides.* *Gleichenia linearis.* *Marattia fraxinea.* *Angiopteris evecta.*	*Trichomanes cupressoides.* *Dryopteris cucullata.* *Odontosoria chinensis.* *Asplenium tenerum.* *A. affine.* *A. bulbiferum.* *Antrophyum immersum.* *A. callifolium.* *Schizæa digitata.* *Ophioglossum pendulum.*	*Dryopteris parasitica.* *Polystichum adiantiforme.* *Nephrolepis cordifolia.* *N. biserrata.* *Asplenium lunulatum.* *A. caudatum.* *Pteris biaurita.* *P. quadriaurita.* *Histiopteris incisa.* *Elaphoglossum conforme.* *Acrostichum aureum.*

distribution of the different species. Not considering the 11 cosmopolitan species, the remaining 65 species can be sorted into three groups :—

I. 9 (4+5) species have their centre in tropical America, 5 of these reaching their eastern limit in the Seychelles.

II. 28 (10+6+12) are confined to Africa, including the islands; 18 of these are not found in tropical Africa, but are endemic in the South-eastern islands, and 12 species are endemic in the Seychelles. Nearly all these endemic species may be regarded as specialized forms of groups which are richly developed in other regions, perhaps with the exception of *Pteris Barklyæ*, a peculiar species, which is probably most closely related to the Mascarene *Ochropteris*. If we take the relationship of the endemic species into consideration, we find that some of them point westwards (*Dryopteris Wardii*, *Polypodium Pervillei*, *Elaphoglossum Hornei*), others eastwards (*Leptochilus bipinnatifidus*, *Lindsaya Kirkii*, *L. Hornei*), while *Asplenium complanatum*, *Stenochlæna Pervillei*, and perhaps *Polypodium albobrunneum* are members of groups specially developed in the Mascarene and other South-eastern African islands.

III. 28 (18+10) species have their maximum in tropical Asia and Polynesia; 10 of these reach their western limit in the South-eastern African islands, and among these there are 4 species (*Asplenium tenerum*, *A. bulbiferum*, *Antrophyum callifolium*, and *Schizæa digitata*) which have their western boundary in the Seychelles.

The above may be summarized thus: the fern-flora of the Seychelles is a mixture of western and eastern species, the latter being in majority. Five species here reach their eastern limit, four their western. The fern-flora as a whole shows no peculiar character; 16 per cent. of the species are endemic.

From the Aldabra group only one species is known, the common mangrove fern, *Acrostichum aureum.*

HYMENOPHYLLACEÆ.

1. TRICHOMANES EROSUM, Willd. (?); Baker, Fl. Maur. 464; C. Chr. Ind. 639.—? *T. cuspidatum*, Kuhn, Bot. v. Ost-Afr. 68.

Common in the mountain forests, *Horne*. Silhouette, 2000 feet on trees, *Gardiner*!

It is with the greatest doubt that I refer the specimens from the Seychelles to *T. erosum*, Willd., which is a West-African species. In general habit the small leaves agree much more with *T. cuspidatum*, Willd., but they differ in the lack of an intramarginal, spurious vein and in the more distinct midrib and lateral veins. The fronds vary in shape, from circular and entire to triangular-oblong, 3 cm. long by 1–1¼ cm. broad, and irregularly repand or serrate, not regularly pinnatifid as in the true *T. erosum*. The form may be specifically distinct from *T. erosum* as well as from *T. cuspidatum*.

2. TRICHOMANES CUPRESSOIDES, Desv. Prodr. 330, 1827; C. Chr. Ind. 638.—*T. obscurum*, var. *pectinata*, Mett.; Kuhn, Fil. Afr. 35. *T. rigidum*, Baker, Fl. Maur. 465.

Mahé, Silhouette, and Long Island, *Gardiner*! A typical fern on rocks on mountains, 2000–2500 feet.

This species, which was originally described from plants from the Seychelles, is common in all the South-east African islands. The Malayan *T. obscurum*, Blume, is very similar and very likely not specifically different.

3. HYMENOPHYLLUM POLYANTHOS, Sw.; Baker, Fl. Maur. 462; C. Chr. Ind. 366.

Mahé, *Horne*, 146! *Gardiner*! Silhouette, on trees, 2000 feet, *Gardiner*!

Also found in Madagascar and tropical West Africa and widely spread in tropical America. A closely allied species, *H. Blumeanum*, Spr., occurs in tropical Asia.

4. HYMENOPHYLLUM CILIATUM, Sw.; Baker, Fl. Maur. 462; C. Chr. Ind. 358.

Mahé, *Gardiner*! Widely spread in the tropics.

5. HYMENOPHYLLUM HYGROMETRICUM (Poir.), Desv.; Baker, Fl. Maur. 463; C. Chr. Ind. 362.

Mahé, *Pervillé, Horne, Gardiner*! in jungle anywhere and at any altitude, on trees or rocks. Silhouette, *Gardiner*!

The species is confined to the South-east African islands.

CYATHEACEÆ.

6. CYATHEA SECHELLARUM, Mett.; Baker, Fl. Maur. 467.

Mahé, *Horne*, 203! Silhouette, *Gardiner*!

Endemic.—I quote from the labels. Horne says: "Common at and above 1000 ft. in Mahé. Trunk in ravines 40–50 ft. Stipe 1–2 ft. Frond 4–9 ft. long, 2–4 ft. broad." Gardiner: "Part of a tree-fern [from the summit of the island of Silhouette, above 2120 ft.]. There are no trunks; the base rising only about 6 in. above ground." Gardiner's specimen is sterile and may, of course, have been taken from a young plant without a developed caudex. It is surprising that Gardiner did not collect the species in Mahé, where in 1871 it was common, according to Horne, which suggests that it is nearly or quite extinct. [It is still found in the indigenous jungles of the hill-tops of Central Mahé, but is disappearing. It was in a press from Mount Harrison which went astray.—J. S. G.]

POLYPODIACEÆ.

7. DRYOPTERIS STRIGOSA (Willd.), C. Chr. Ind. 295.—*Aspidium strigosum*, Willd.; Kuhn, Bot. v. Ost-Afrika, 37. *Nephrodium tomentosum*, Baker, Fl. Maur. 496, pro parte.

I list this species with some doubt among the ferns of the Seychelles, as I have seen only a single, rather scanty specimen from the islands (*Horne*, 678), determined by Baker as *Nephrodium tomentosum*. It does not belong to the true *Dryopteris tomentosa* (Thouars), but rather to *D. strigosa* (Willd.), according to Kuhn's delimitation of that species. Still the determination is rather doubtful the basal pair of veins is truly united. The species is known from the Mascarenes and Madagascar.

8. Dryopteris parasitica (Linn.), O. Kuntze; C. Chr. Ind. 282.—*Nephrodium molle*, Baker, Fl. Maur. 499.

Mahé, *Horne*, 202!

The species taken in a broad sense is common in all tropical and subtropical regions. The form growing in the Seychelles is scarcely conspecific with the common American *D. mollis* (Jacq.), Hieron.

9. Dryopteris cucullata (Blume), Christ, Philippine Journ. Sci. Bot. ii. 194, 1907.—*Nephrodium cucullatum*, Baker, Fl. Maur. 498. *Dryopteris unita* (Linn.), O. Kuntze; C. Chr. Ind. 299.

Mahé, Silhouette, and Long Island, *Gardiner*! Typical fern of open spaces. 1000-2000 feet.

Distribution. Through tropical Asia and Polynesia, and common in the South-east African islands.

10. Dryopteris mauritiana (Fée), C. Chr.—*Nephrodium elatum*, var. *mauritianum*, Baker, Fl. Maur. 499.—*Aspidium procerum*, Bojer; Kuhn, Bot. v. Ost-Afrika, 41 (with description).

Var. Gardineri, C. Chr. (var. nov.).

A forma typica differt: *pinnis* brevioribus, ad 12 cm. longis 2 cm. basi latis, atroviridibus, tenuiter membranaceis, ad costas costulasque supra albido-setosis, infra breviter et sparse hirtis, inter venas utrinque glabris, infra glandulis sessilibus subdense glandulosis; *laciniis* vix obliquis, obtusis; *venis* 8–10-jugis, pellucidis, basalibus 2–4 alternatim unitis; *indusiis* magnis, glabris.

Silhouette, *Gardiner*, Aug. 2, 1908. Mahé, *H. P. Thomasset* (this is more like the type).

The typical form of *D. mauritiana* was found previously in the Mascarenes and Comoros. The species is new to the Seychelles. The single leaf collected measures $1\frac{1}{2}$ m. in length on a stipe scarcely 10 cm. long; it narrows downwards rather gradually through about 15 pairs of auriculiform pinnæ, $\frac{1}{2}$–2 cm. long and broad, and hastate. It differs from the type mainly in the glandular underside and its patent, obtuse segments. The pinnæ taper from a broad base towards the acuminate apex.—I am inclined to believe that *Aspidium elatum*, Bojer, from Mauritius is specifically distinct.

11. Dryopteris Wardii (Baker), O. Kuntze; C. Chr. Ind. 301.—*Nephrodium Wardii*, Baker, Trans. R. Irish Acad. xxv. (1875), tab. 30; Fl. Maur. 496.

Mahé, *Ward*! *Horne*, 177! *Gardiner*! Silhouette, *Gardiner*!

Endemic. Rhizome horizontal, about 2 cm. thick, densely covered with glossy, brown, narrow acuminate scales, 1–2 cm. long. Stipe about 25 cm. long, slightly scaly at the base. Lamina about 50 cm. long, 40 cm. broad at the base, entirely glabrous. In habit not unlike *D. effusa* (Sw.), Urban, of tropical America.

12. Dryopteris Hornei (Baker), O. Kuntze; C. Chr. Ind. 271.—*Nephrodium Hornei*, Baker, Fl. Maur. 497.

Mahé, *Horne*, 182! Silhouette, *Horne*, 685!

Endemic. The pubescence is peculiar, the costæ and costulæ above are rufous-tomentose from short, articulated hairs (the typical pubescence of my subgenus *Ctenitis*); the veins beneath are densely covered with very short and thick, appressed glandular hairs, which in well-preserved specimens are glossy, golden yellow, in old specimens whitish, meal-like. I remember only one species which shows a similar pubescence, viz. *D. chrysotricha* (Baker), C. Chr., from Samoa, but in that the hairs are bright yellow.

13. Aspidium pleiotomum (Baker), Kuhn; C. Chr. Ind. 88.—*Nephrodium pleiotomum*, Baker, Tr. Roy. Irish Acad. xxv. (1875), tab. 31 b; Fl. Maur. 500.

Mahé, *Horne*. Silhouette, *Gardiner*!

Also Madagascar, fide *Baker*.

14. Polystichum adiantiforme (Forst.), J. Sm.; C. Chr. Ind. 578.—*Aspidium capense*, Willd.; Baker, Fl. Maur. 492. *Aspidium coriaceum*, Sw.; Kuhn, Bot. v. Ost-Afrika, 69.

Mahé and Silhouette, *Gardiner*! Sometimes partially epiphytic.

Distribution. Australia and Southern Polynesia. South Africa and adjacent islands. America from Cuba and Jamaica to Fuegia. A common species in most oceanic islands of the southern hemisphere. The numerous specimens collected by Gardiner are rather different, especially in size; some of them are scarcely more than bipinnatifid with a lamina not more than 10 cm. long, but fully fertile.

15. Leptochilus bipinnatifidus (Mett.), C. Chr. comb. nov.—*Chrysodium bipinnatifidum*, Mett.; Kuhn, Fil. Afr. 50. *Acrostichum repandum*, Baker, Fl. Maur. 514 (non Blume).

Mahé, *Boivin*! *Gardiner*! Silhouette, near the summit, *Gardiner*!

Perhaps endemic. It is also recorded from Réunion (*coll. Boivin*); but Jac. de Cordemoy has not seen it. All Boivin's specimens in the Museum of Paris seen by me are from the Seychelles.

I now think that this can safely be regarded as a species distinct from the Asiatic and Polynesian *L. cuspidatus*, C. Chr. (*Acrostichum repandum*, Blume). It differs in the more deeply cut pinnæ, which are truncate at the base, not cuneate, and in the more decidedly scaly costæ. The lowermost pinnæ are rather unequal-sided, the upper ones decurrent at the lower base, and the fertile pinnæ deeply cut into bluntly rounded lobes. The sterile fronds often have rooting tips.

16. Oleandra articulata (Sw.), Presl; Baker, Fl. Maur. 493; C. Chr. Ind. 466.

Mahé, *Gardiner*! Silhouette, near the summit, *Gardiner*! "Epiphytic, notable climber."

Distribution. Through tropical Africa to Cape Colony, and especially common in the South-east African islands.

17. Nephrolepis cordifolia (Linn.), Presl; Baker, Fl. Maur. 493; C. Chr. Ind. 453.—*N. tuberosa*, Presl; Kuhn, Bot. v. Ost-Afr. 69.

Seychelles, teste *Baker*. A cosmopolitan tropical species.

18. Nephrolepis biserrata (Sw.), Schott; C. Chr. Ind. 453.—*N. exaltata*, var. *biserrata*, Baker, Fl. Maur. 493.

Mahé, Silhouette, Long Island, Bird Island, *Gardiner*!

19. Humata repens (Linn. f.), Diels; C. Chr. Ind. 354.—*Davallia pedata*, Sw.; Baker. Fl. Maur. 468.

Mahé and Silhouette, *Gardiner*! Climber, dominant near the tops of trees; also in moss of the highest jungle in open places, Morne Pilot, 2700 feet, Mahé.

Distribution. From the South-east African islands through tropical Australia and Asia to Japan.

20. Davallia chærophylloides (Poir.), Steud.; C. Chr. Ind. 208.—*D. elata*, Baker, Fl. Maur. 469. *D. denticulata*, var. *intermedia*, Mett.; Kuhn, Fil. Afr. 158.

Mahé and Silhouette, *Gardiner*! Common in jungle, everywhere. In Silhouette it is said to be "a glacis fern, growing in moister holes in the rock." The fertile frond is densely glandulose throughout. The species is an African representative of and nearly related to the Asiatic and Polynesian *D. denticulata* (Burm.), Mett.; it is known from tropical West Africa, Natal, the Comoros, Madagascar, Mauritius, Rodriguez, and the Seychelles.

21. Microlepia speluncæ (Linn.), T. Moore; C. Chr. Ind. 428.—*Davallia speluncæ*, Baker, Fl. Maur. 469.

Mahé, *Gardiner*! *Thomasset*!

Cosmopolitan in the tropics of the Old World.

22. Odontosoria chinensis (Linn.), J. Sm.; C. Chr. Ind. 464.—*Lindsaya chinensis*, Mett.; Kuhn, Fil. Afr. 67. *Davallia tenuifolia*, Sw.; Baker, Fl. Maur. 469.

Seychelles (fide *Baker*, not seen).

Distribution. From Japan through tropical Asia and Polynesia and again in the South-east African islands.

23. Schizoloma ensifolium (Sw.), J. Sm.; C. Chr. Ind. 618.—*Lindsaya ensifolia*, Sw.; Baker, Fl. Maur. 472.

Mahe, *Gardiner*! *Thomasset*!

Distributed through the tropics of the Old World.

24. Lindsaya Kirkii, Hook.; Baker, Trans. R. Irish Acad. xxv. (1875), tab. 28; Fl. Maur. 473; C. Chr. Ind. 394.—*L. Pervillei*, Mett.; Kuhn, Fil. Afr. 17 et 68.

Mahé, *Gardiner*! *Thomasset*. Silhouette, *Gardiner*!

Endemic. A large pretty species, common in the islands, growing on the ground and often partially epiphytic.

25. Lindsaya Hornei (Baker), C. Chr. Ind. 210 (omitted under *Lindsaya*).—*Davallia Hornei*, Baker, Fl. Maur. 470.

Mahé, *Horne*, 677!

Endemic, common *fide* Horne, but not collected by Gardiner. It is a true *Lindsaya*, but a rather problematic species. It is, perhaps, a small form of *L. Kirkii*, with which it agrees in soral characters and basal scales; still the shape of the segments is somewhat different, their lower edge being much upcurved while in *L. Kirkii* it is decurved.

26. Diplazium sechellarum (Baker), C. Chr. Ind. 238.—*Asplenium sechellarum*, Baker, Fl. Maur. 491.

Mahé, *Bouton*! *Horne*! "Common in the damp shady forests," but not collected by Prof. Gardiner.

According to Baker also found in Madagascar. It is a large, tripinnatifid species, related to the Asiatic *D. polypodioides*, Blume, characterized by the muricated rachis.

27. Asplenium nidus, Linn.; Baker, Fl. Maur. 491; C. Chr. Ind. 123.

Mahé, *Gardiner*! *Thomasset*! Silhouette, *Gardiner*!

Distribution. Through tropical Polynesia, Australia, and Asia, extending westwards to tropical West Africa.

28. Asplenium unilaterale, Lam.; C. Chr. Ind. 136.—*A. resectum*, Sm.; Baker, Fl. Maur. 485.

Seychelles, *Kirk*!

Distribution. Through the tropics of the Old World.

29. Asplenium lunulatum, Sw.; Baker, Fl. Maur. 486.

Mahé, *Horne*, 404 (not seen).

Distribution. Regarded as a collective species, *A. lunulatum* is widely spread through the tropics; the typical form is South African.

30. Asplenium tenerum, Forst.; Baker, Fl. Maur. 486; C. Chr. Ind. 134.

Mahé, *Horne*, 684!

Spread through tropical Polynesia and Asia; it is not known from the other African islands.

31. Asplenium (Euasplenium) complanatum, C. Chr. (sp. nov.). (Pl. 45. figs. 1–3.)

Rhizoma obliquum, fere 1 cm. crassum, squamis parvis, ovatis, nigrescentibus, subdense onustum. *Stipites* numerosi, subapproximati, virides, glabri, complanati, supra late

canaliculati, sursum anguste alati, ad 7 cm. longi. *Lamina* pinnata, lanceolata, usque ad 20 cm. longa, 5 cm. lata, versus apicem pinnatifidum seu grosse serratum, breviter acuminata, viridis, omnino glabra, textura carnosula. *Rachis* complanata, a basi ad apicem alata, alis 1 mm. latis. *Pinnæ* numerosæ, 2½ cm. longæ, 1 cm. latæ, suberectæ, inferiores vix abbreviatæ, breviter petiolatæ, ad rachin articulatæ, basi inferiore cuneatæ, superiore truncatæ, sæpe subauriculatæ, marginibus apiceque obtuso grosse serratis. *Venæ* indistinctæ, simplices, obliquæ. *Sori* mediales, 1–2 mm. longi, 1 mm. lati, indusiis margine integris.

Silhouette, *Gardiner*!

This new species resembles the Australian *A. obtusatum*, Forst., in colour and texture and the short thick sori, but in general habit it is not unlike *A. tenerum*, from which it differs in its short sori, fleshy texture, and winged rachis. It is a well-known fact that several pinnate species of *Asplenium* vary extraordinarily in cutting. The most cut forms are often dareoid, *i.e.* the ultimate segments are narrow with the sori marginal. Such dareoid varieties look very different from the pinnate forms of the same species, and they are commonly described as proper species. It has, however, been proved by botanists who have studied the different forms in the field that certain old species of *Darea* really are dareoid forms of species which, in the "normal" state, are pinnate only. Thus is *Darea bifida*, Bory, the dareoid variety of *A. lineatum*, Sw.; *D. Belangeri*, Bory, of *A. tenerum*. Dareoid forms are especially common in the Mascarenes and South Africa, and some of them are not known in the pinnate state. My proposed new species, *A. complanatum*, may be the pinnate form of a species which so far is known as dareoid only, viz. *Asplenium borbonicum*, Hook., a species from Réunion and Mauritius, but not known from the Seychelles. It is very probable that such is the case, but I cannot prove it at present, and I therefore think it best to describe the new form as a new species.

32. Asplenium caudatum, Forst.; Baker, Fl. Maur. 488; C. Chr. Ind. 104.

Mahé, *Horne*, 668! *Thomasset*! Silhouette, *Gardiner*! "A typical fern of the 1000–2000 feet zone in fairly open places."

Var. minor, C. Chr. (var. nov.):—Lamina 20 cm. longa, pinnis 3 cm. longis, ½–1 cm. latis, apice acutis nec caudatis.

Mahé and Silhouette, *Gardiner*!

This variety is a very doubtful form, in size and general habit very much resembling *A. pellucidum*, Lam., to which species Baker (Fl. Maur. 487) referred a specimen from the Seychelles (*coll. Kirk*!). It differs from that species in its lower pinnæ being not at all reduced. I think I am right in considering it a small form of *A. caudatum*, from which it differs in its small size and non-caudate pinnæ, whilst it agrees with it in colour, texture, pubescence, and other characters. A specimen from Silhouette (*Gardiner*) is exactly intermediate between the large *A. caudatum* and the variety.

A. caudatum is a cosmopolitan tropical species.

33. Asplenium affine, Sw.; C. Chr. Ind. 100.—*A. cuneatum*, var. *affine*, Baker, Fl. Maur. 489.

Mahé, *Gardiner*! *Thomasset*!

Distribution. Common in the South-east African islands; tropical Asia and Polynesia. It may be a variety of *A. cuneatum*, Lam., the typical form of which is West Indian. Some of the leaves are proliferous at the apex (conf. *A. viviparioides*, Kuhn).

34. Asplenium bulbiferum, Forst.; Baker, Fl. Maur. 489; C. Chr. Ind. 103.

Seychelles, *Kirk* (fide *Baker*, not seen).

Whether this is the true *A. bulbiferum*, Forst., I cannot say. Kuhn did not list *A. bulbiferum* as an African species.

35. Stenochlæna Pervillei (Mett.), Underw. Bull. Torr. Club, xxxiii. (1906), 49, fig. 1.—*Lomariopsis Pervillei*, Mett.; Kuhn, Fil. Afr. 53. *Acrostichum sorbifolium*, Baker, Fl. Maur. 513.

Mahé, *Gardiner*! *Thomasset*!; common over 1000 feet. Silhouette, *Gardiner*!; rare epiphytic climber.

Endemic. The upper base of the sterile pinnæ is commonly nearly parallel to the rachis, and not so cuneate as shown in Underwood's figure quoted above.

36. Stenochlæna tenuifolia (Desv.), T. Moore; C. Chr. Ind. 626.—*Acrostichum tenuifolium*, Baker, Fl. Maur. 513. *Polybotrya tenuifolia*, Kuhn, Fil. Afr. 52.

Seychelles, *Pervillé*, 464 (fide *Kuhn*, not seen).

Distribution. Tropical and South Africa, with the adjacent islands.

37. Ceropteris calomelanos (Linn.), Underw.; C. Chr. Ind. 169.

Mahé, *Gardiner*!

An American species, probably introduced, as in several tropical countries in the Old World.

38. Pellæa Doniana, Hook.; Baker, Fl. Maur. 477; C. Chr. Ind. 479.

Mahé, *Gardiner*! *Thomasset*! Silhouette, *Gardiner*! "This fern occurs right down in the mangroves at Grande Barbe."

Spread through tropical Africa; not known from the other islands.

39. Pellæa viridis (Forsk.), Prantl; C. Chr. Ind. 483.—*P. hastata*, Link; Baker, Fl. Maur. 478. *Pteridella viridis*, Mett.; Kuhn, Bot. v. Ost-Afr. 16.

Seychelles (fide *Baker*, not seen).

Through tropical Africa to the Cape and the South-eastern islands.

40. Adiantum caudatum, Linn.; Baker, Fl. Maur. 471, part.; C. Chr. Ind. 24.

Seychelles, *Kersten*, 9 (fide *Kuhn*, not seen).

Tropical Africa and Asia.

41. ADIANTUM RHIZOPHORUM, Sw.; Kuhn, Fil. Afr. 66; C. Chr. Ind. 33.—*A. caudatum*, part., Baker, Fl. Maur. 474.

Seychelles, *Pervillé*, 212 (fide *Kuhn*, not seen).

Southern Africa and adjacent islands.

42. ACTINIOPTERIS AUSTRALIS (Linn. fil.), Link; C. Chr. Ind. 21.—*Pteris dichotoma*, var. *elongata*, Mett.; Kuhn, Fil. Afr. 80. *P. dichotoma*, Baker, Fl. Maur. 481. *Actiniopteris dichotoma*, Mett.; Kuhn, Bot. v. Ost-Afr. 68.

Seychelles, *Pervillé* (fide *Kuhn*, not seen).

Distributed from Africa with the South-eastern islands to tropical Asia.

43. PTERIS BARKLYÆ (Hook.), Mett.; Kuhn, Fil. Afr. 77 (as *Barkleyæ*).—*Pellæa Barklyæ*, Baker, Fl. Maur. 477; C. Chr. Ind. 478.

Seychelles, *Kirk*! *Lady Barkly*! *Gardiner*! (Mahé).

Endemic. A very distinct species, the proper place of which must be in the genus *Pteris*. The essential difference between *Pellæa* and *Pteris* is the different habit; in soral characters the two genera agree. In *Pellæa* the sterile tips of the fertile segments are entire, in *Pteris* nearly always distinctly serrated; in this character the present species agrees with *Pteris*. It is perhaps nearest related to *Ochropteris pallens* (Sw.), J. Sm., from the Mascarenes, resembling it closely in cutting, but the sori are truly pteridoid and the rachis is purplish and polished.

44. PTERIS BIAURITA, Linn.; Baker, Fl. Maur. 481; C. Chr. Ind. 593.

Seychelles (fide *Baker*, not seen).

45. PTERIS BIAURITA, Linn., subsp. P. QUADRIAURITA, Retz.; Baker, Fl. Maur. 480.—*P. nemoralis*, Willd.; Kuhn, Fil. Afr. 86.

Seychelles, *Kersten*, 20 (fide *Kuhn*). Mahé, *Gardiner*!

P. biaurita, with its subspecies *quadriaurita*, is cosmopolitan in the tropics.

46. PTERIS ATROVIRENS, Willd.; Baker, Fl. Maur. 482; C. Chr. Ind. 593.

Mahé, *Horne*, 652 (fide *Baker*, not seen).

Spread through tropical Africa; not found in the other islands of the Indian Ocean.

47. PTERIS TRIPARTITA, Sw.; C. Chr. Ind. 608.—*P. marginata*, Bory; Baker, Fl. Maur. 482.

Silhouette, *Gardiner*! *Pervillé* (fide *Kuhn*).

Spread through the tropics of the Old World.

48. HISTIOPTERIS INCISA (Thunb.), J. Sm.; C. Chr. Ind. 352.—*Pteris incisa*, Baker, Fl. Maur. 483.

Mahé, *Gardiner*! *Pervillé*, 75 (fide *Kuhn*).

Through the tropics and the southern temperate regions.

49. Lonchitis pubescens, Willd.; Baker, Fl. Maur. 475; C. Chr. Ind. 409.—*L. hirsuta*, Kuhn, Bot. v. Ost-Afr. 10.

Seychelles, *Kirk* (fide *Baker*, not seen).

Through tropical and Southern Africa, with the Eastern islands.

50. Monogramma graminea (Poir.), Schkuhr; Baker, Fl. Maur. 501; C. Chr. Ind. 430.

Seychelles, *Pervillé* (fide *Kuhn* and *Baker*, not seen).

Confined to the Seychelles and Mascarenes.

51. Vittaria elongata, Sw., var. ensiformis (Sw.).—*V. ensiformis*, Sw.; C. Chr. Ind. 653. *V. plantaginea*, Bory; Kuhn, Fil. Afr. 55. *V. elongata*, Baker, Fl. Maur. 471.

Silhouette, 2000 feet, *Gardiner*!

The variety is probably confined to the Mascarenes and Seychelles; the species, in several forms, is widely spread through the tropics of the Old World.

52. Vittaria isoetifolia, Bory; Kuhn, Fil. Afr. 55; C. Chr. Ind. 654.—*V. lineata*, Baker, Fl. Maur. 471.

Mahé, *Gardiner*! *Thomasset*! Silhouette, *Gardiner*!

South Africa and adjacent islands. The determination is rather doubtful.

53. Vittaria scolopendrina (Bory), Thwait.; Baker, Fl. Maur. 471; C. Chr. Ind. 655.

Mahé and Silhouette, near the summit, *Gardiner*!

Distribution. From Mozambique through tropical Asia to Samoa.

54. Antrophyum immersum (Bory), Mett.; Baker, Fl. Maur. 509; C. Chr. Ind. 60.

Seychelles (fide *Baker*, not seen).

Mascarenes, Seychelles, and Malesia.

55. Antrophyum callifolium, Blume; C. Chr. Ind. 59.—*A. reticulatum*, Baker, Fl. Maur. 509.

Mahé, *Horne*, 683! Silhouette, near summit, very scarce, *Gardiner*!

Distribution. Malesia, Polynesia, Seychelles.

According to Mettenius's description in Ann. Mus. Lugd.-Bat. iv. 171, this is *A. callifolium*, not *A. reticulatum* (Forst.), Kaulf.

56. Hymenolepis spicata (Linn. fil.), Pr.; C. Chr. Ind. 356.—*Acrostichum spicatum*, Linn. fil.; Baker, Fl. Maur. 514.

Seychelles (fide *Baker*, not seen).

Spread through the tropics of the Old World, continental Africa excluded; common in the South-east African islands.

57. Polypodium Pervillei, Mett.; Kuhn, Fil. Afr. 150; Baker, Trans. R. Irish Acad. xxv. tab. 31 a; Fl. Maur. 504; C. Chr. Ind. 552.

Mahé, *Pervillé*! *Gardiner*! On rocks in streams or damp tree-trunks over 1000 feet. Endemic.

58. Polypodium serrulatum (Sw.), Mett.; Baker, Fl. Maur. 504; C. Chr. Ind. 563.
Mahé, *Thomasset*!

Distribution according to Hieronymus ('Hedwigia,' vol. xliv. 80):—Tropical America (common), tropical West Africa, Madagascar, Mascarenes, Seychelles.

59. Polypodium albobrunneum, Baker, Fl. Maur. 505; C. Chr. Ind. 508.—*P. sechellarum*, part., Baker, Fl. Maur. 505.

Mahé, *Horne*, 681! 682! *Gardiner*! *Thomasset*! Silhouette, near the summit, scarce; epiphyte high up on trees.

Endemic.

P. sechellarum, Baker, was founded partly on a small sterile plant from Mahé (*Horne*, n. 194) and partly on a single leaf from Mauritius (*Lady Barkly*), both of which I have seen. The description in Fl. Maur. is evidently written from the Mauritian specimen, which belongs to a species distinct from *P. albobrunneum*. The specimen from Mahé is, I have no doubt, only a small sterile plant of *P. albobrunneum*; some of the rather numerous specimens collected by Gardiner agree exactly with it. *P. sechellarum*, Baker, is thus not known from the Seychelles, and the name therefore is very inappropriate.

60. Polypodium cultratum, Willd., var. elasticum (Bory).—*P. elasticum*, Bory. *P. asplenifolium*, var. *minor*, Mett.; Kuhn, Fil. Afr. 146. *P. cultratum*, Baker, Fl. Maur. 505.

Mahé, on tree-trunks over 2000 feet, rather scarce, *Gardiner*! *Thomasset*!

P. cultratum (type) is a tropical American species, and is also found in the island of Fernando Po, Guinea. The variety *elasticum* is apparently confined to the Mascarenes and Seychelles. It is very like the type, especially some of its smaller forms, but it is more hairy, with longer and shorter hairs mixed on the upper surface and along the margins.

61. Polypodium punctatum (Linn.), Sw.; C. Chr. Ind. 557.—*P. irioides*, Lam.; Baker, Fl. Maur. 507.

Mahé, *Thomasset*!

Through the tropical regions of the Old World.

62. Polypodium phymatodes, Linn.; Baker, Fl. Maur. 508; C. Chr. Ind. 553.

Mahé, *Gardiner*! *Thomasset*! Bird Island, in dry places, *Fryer*! Long Island, *Gardiner*! Silhouette, *Gardiner*!

Distribution. From South Africa through tropical Africa, Asia, Australia, and Polynesia to Corea.

63. Cyclophorus spissus (Bory), Desv.; C. Chr. Ind. 201.—*Polypodium spissum*, Bory; Kuhn, Fil. Afr. 153. *P. adnascens*, Baker, Fl. Maur. 506.

Seychelles (fide *Kuhn* and *Baker*, not seen).

South Africa and the Eastern islands; scattered through tropical Asia.

64. Elaphoglossum martinicense (Desv.), T. Moore, var. obtusum, C. Chr. (var. nov.).—*Acrostichum simplex*, var. *martinicense*, Baker, Fl. Maur. 510.

Mahé, *Horne*, 676! *Gardiner*! Not uncommon in Mahé and Silhouette (*Horne*).

Differs from the typical *E. martinicense* of the West Indies, which certainly is specifically different from *E. simplex*, by the shortly acute or rounded-obtuse apex of the lamina (not long and gradually acuminate) and by the long decurrent base of the sterile frond, the stipe being winged nearly to the base. Sterile lamina 10–20 cm. long by 1 cm. broad, very coriaceous; fertile lamina shorter but of the same breadth on a much longer stipe. This variety may be the same as *Acrostichum lineatum*, Kuhn (Christ. Mon. Elaph. 146), from Madagascar, but that is said to have a stipe 10 cm. long. Other similar forms are found in tropical West Africa. The true *E. martinicense* is probably confined to the West Indian islands.

65. Elaphoglossum conforme (Sw.), Schott; C. Chr. Ind. 304.—*Acrostichum conforme*, Sw.; Baker, Fl. Maur. 511.

Mahé and Silhouette, *Gardiner*!

Through the tropical regions.

66. Elaphoglossum latifolium (Sw.), J. Sm.; C. Chr. Ind. 309.—*Acrostichum latifolium*, Sw.; Baker, Fl. Maur. 511.

Mahé and Silhouette, *Gardiner*!

I follow Baker in referring the fern in question to *E. latifolium*, which by some authors is considered an exclusively American species. I really cannot see how the specimens can be safely distinguished from the American form. Christ, in his monograph of the genus, refers all the large glabrous forms of *Elaphoglossum* from the South-east African islands to *E. Sieberi* (Hook. & Grev.); but that species is said to have linear-subulate, almost black scales; our specimens have, however, light brown lanceolate scales, resembling those of the genuine *E. latifolium*. I am inclined to believe that the form from the Seychelles is just the same as *Acrostichum ellipticum*, Fée, Acrost. tab. 4, referred by Baker to *E. Sieberi*; Fée describes the scales as "aurantiaco-rufidulis." It resembles also very much the Javan *E. callifolium* (Blume), T. Moore. Kuhn (Bot. v. Ost-Afr. 69) lists *E. Sieberi* among the ferns of the Seychelles, but his *A. Sieberi* is no doubt the same as *E. latifolium* as understood here.

E. latifolium is widely distributed in tropical America; a form very much resembling that from the Seychelles is known from the Comoros.

67. Elaphoglossum Hornei, C. Chr. (sp. nov.). (Pl. 45. figs. 4–7.)

Syn.: *Acrostichum viscosum*, var. *glabrescens*, Baker, Fl. Maur. 512 (non *A. glabrescens*, Kuhn).

Rhizoma breviter repens, paleis rufis crispis anguste linearibus subintegris dense onustum. *Stipites* dense fasciculati, stricti, parce paleacei denique nudi, $1\frac{1}{2}$–2 mm. crassi, 5–7 cm. longi. *Lamina* sterilis lanceolata, usque ad 35 cm. longa, medio 4 cm. lata, apice breviter attenuata, acuta, basi longe cuneata, papyracea vel subcoriacea, præter costam paleis minutis rufis laceratis subtus parce instructam ubique

nuda. *Venæ* plerumque furcatæ, intra marginem callosam apicibus subclavatis desinente. *Lamina* fertilis similis, 15–17 cm. longa, 2 cm. lata, stipite longiore (10 cm.).

Mahé, *Horne*, 171! (type), *Gardiner*! Silhouette, 2000 feet, *Gardiner*!

I cannot agree with Baker in regarding this as a variety of *E. petiolatum*. It differs from that species in its much larger leaves, its glabrous surfaces, and the different scales of the rhizome. In *E. petiolatum* the scales are dark brown, glossy, very narrow, and nearly hair-like. In general habit our new species resembles not a little *E. flaccidum*.

68. Elaphoglossum petiolatum (Sw.), Urb., var. salicifolium (Willd.).—*Acrostichum salicifolium*, Willd. *A. viscosum*, Baker, Fl. Maur. 512.

Mahé and Silhouette, *Gardiner*!; apparently common.

Most specimens are rather densely clothed all over both surfaces with minute pseudo-stellate scales.

E. petiolatum type is common in tropical America; the variety is frequent in the South-east African islands, and Kuhn refers specimens from tropical West Africa to it. Very similar forms occur in Southern China and the Himalaya (*A. neriifolium*, Wall.).

69. Elaphoglossum spathulatum (Bory), T. Moore; C. Chr. Ind. 316.—*Acrostichum spathulatum*, Bory; Baker, Fl. Maur. 512.

Mahé, *Horne* (fide *Baker*, not seen).

Distribution. South Africa with the adjacent islands, Ceylon, tropical America.

70. Acrostichum aureum, Linn.; Baker, Fl. Maur. 514; C. Chr. Ind. 5.

Seychelles; Mahé, *Gardiner*! Silhouette, *Gardiner*! Bird Island, *Fryer*! Aldabra Group, near Pte. Hodone, *R. Dupont*, 36!

71. Platycerium bifurcatum (Cav.), C. Chr. Ind. 496.—*P. alcicorne*, Baker, Fl. Maur. 515.

Seychelles (fide *Baker*, not seen).

East Africa and islands, Australia and New Caledonia, Lord Howe Island.

As suggested in my 'Index,' it is uncertain whether this East-African *Platycerium* is the same as the true *P. bifurcatum* from Australia.

PARKERIACEÆ.

72. Ceratopteris thalictroides (Linn.), Brongn.; C. Chr. Ind. 169.

Mahé, Anse Royale, and Terné, *Gardiner*! Silhouette, Grande Barbe, *Gardiner*!

New to the Seychelles. The true *C. thalictroides* is widely distributed through the Old World tropics, and according to Benedict (Bull. Torr. Club, vol. xxxvi. (1909) 463) it is probably confined to the Old World, the American forms belonging to three different species.

GLEICHENIACEÆ.

73. Gleichenia linearis (Burm.), C. B. Clarke; C. Chr. Ind. 322.—*G. dichotoma*, Baker, Fl. Maur. 460.

Mahé, Silhouette, and Long Island, *Gardiner* !

Common through the tropical and subtropical regions of the Old World, and closely related forms occur in tropical America.

SCHIZÆACEÆ.

74. Schizæa digitata (Linn.), Sw.; C. Chr. Ind. 616.—*S. digitata*, var. *intermedia* (Mett.), Baker, Fl. Maur. 516.

Mahé, *Gardiner* !

This is the genuine *S. digitata*, a species widely distributed through tropical Asia and Polynesia, but, so far as Africa is concerned, known from the Seychelles only. The locality Madagascar is doubtful. Baker referred the Seychelles specimens to *S. intermedia*, a species from New Caledonia distinctly different from *S. digitata* by having the sporangia intermixed with long paraphyses.

MARATTIACEÆ.

75. Marattia fraxinea, Sm.; C. Chr. Ind. 414.

Mahé, *Gardiner* ! New to the group.

Distributed through the tropics of the Old World.

76. Angiopteris evecta (Forst.), Hoffm.; Baker, Fl. Maur. 517.

Mahé and Silhouette, *Gardiner* !

Widely spread through the Old World tropics.

OPHIOGLOSSACEÆ.

77. Ophioglossum pendulum, Linn.; Baker, Fl. Maur. 517; C. Chr. Ind. 471.

Mahé, *Gardiner* ! *Thomasset* ! Silhouette, *Gardiner* ! Apparently common.

Tropical Asia, Australia, and Polynesia, the South-east African islands, but not known from the African continent.

78. Ophioglossum palmatum, Linn.; Kuhn, Fil. Afr. 178; C. Chr. Ind. 471.

Seychelles, *Pervillé* (fide *Kuhn*, not seen).

Florida and tropical America; Madagascar, Réunion, and Seychelles.

EXPLANATION OF PLATE 45.

Fig. 1. *Asplenium complanatum*, natural size.
2. Portion of pinna enlarged, showing sori.
3. Sporangium, enlarged.
4. *Elaphoglossum Hornei*, natural size.
5. Portion of frond, showing venation.
6. Part of fertile frond, enlarged.
7. Sporangium, much enlarged.

M. Smith del.
J. N. Fitch lith.

West, Newman imp.

1-3 ASPLENIUM COMPLANATUM. 4-7 ELAPHOGLOSSUM HORNEI.

LINNEAN SOCIETY OF LONDON.

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s*. to the public, and 6*s*. to Fellows; to Vols. 26–30, 4*s*. to the public, and 3*s*. to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

Second Series.—Botany.

Volume.		When Published.	Price to the Public. £	*s.*	*d.*	Price to Fellows. £	*s.*	*d.*
I.	Parts I.–IX. (complete).	1875–80.	8	1	0	6	1	0
II.	Parts I.–XVI. (complete).	1881–88.	6	16	10	5	2	9
III.	Part I.	1888.	3	12	0	2	14	0
	Part II.	1891.	0	5	0	0	3	9
	Part III.	1891.	0	7	0	0	5	0
	Part IV.	1891.	0	6	0	0	4	6
	Part V.	1891.	0	6	0	0	4	6
	Part VI.	1891.	0	3	6	0	2	8
	Part VII.	1892.	0	6	0	0	4	6
	Part VIII.	1893.	0	6	0	0	4	6
	Part IX.	1893	1	8	0	1	1	0
	Part X.	1894.	0	10	0	0	7	6
	Part XI.	1894.	0	3	4	0	2	6
IV.	Part I.	1894.	1	0	0	0	15	0
	Part II.	1894.	2	0	0	1	10	0
	Part III.	1895.	2	10	0	1	17	0
	Part IV.	1895.	0	3	4	0	2	6
V.	Part I.	1895.	0	9	0	0	6	9
	Part II.	1896.	0	12	0	0	9	0
	Part III.	1896.	0	6	0	0	4	6
	Part IV.	1896.	1	0	0	0	15	0
	Part V.	1896.	0	14	0	0	10	6
	Part VI.	1896.	0	4	0	0	3	0
	Part VII.	1897.	0	4	0	0	3	0
	Part VIII.	1897.	0	6	0	0	4	6
	Part IX.	1899.	0	12	0	0	9	0
	Part X.	1899.	0	6	0	0	4	6
	Part XI.	1899.	0	7	0	0	5	0
	Part XII.	1899.	0	12	0	0	9	0
	Part XIII.	1900.	0	1	6	0	1	2
	Part XIV.	1900.	0	3	0	0	2	3
	Part XV.	1901.	0	6	0	0	4	6
VI.	Part I.	1901.	1	10	0	1	2	6
	Part II.	1901.	0	6	0	0	4	6
	Part III.	1902.	0	18	0	0	13	6
	Part IV.	1903.	0	8	0	0	6	0
	Part V.	1903.	0	8	0	0	6	0
	Part VI.	1903.	0	12	0	0	9	0
	Part VII.	1904.	0	12	0	0	9	0
	Part VIII.	1904.	0	12	0	0	9	0
	Part IX.	1904.	0	7	0	0	5	3
	Part X.	1904.	0	14	0	0	10	6
	Part XI.	1905.	0	4	0	0	3	0
VII.	Part I.	1904.	0	5	0	0	3	9
	Part II.	1905.	0	6	0	0	4	6
	Part III.	1906.	0	3	0	0	2	3
	Part IV.	1906.	0	7	0	0	5	3
	Part V.	1907.	0	10	0	0	7	6
	Part VI.	1907.	0	4	0	0	3	0
	Part VII.	1907.	0	6	0	0	4	6
	Part VIII.	1908.	0	5	0	0	3	9
	Part IX.	1908.	0	2	6	0	2	0
	Part X.	1908.	0	7	0	0	5	3
	Part XI.	1909.	0	4	0	0	3	0
	Part XII.	1909.	0	12	0	0	9	0
	Part XIII.	1909.	0	5	0	0	3	9
	Part XIV.	1909.	0	6	0	0	4	6
	Part XV.	1910.	0	6	0	0	4	6
	Part XVI.	1912.	0	3	0	0	2	3
	Part XVII.	1912.	0	8	0	0	6	0
	Part XVIII.	1912.	0	5	0	0	3	9
	Part XIX.	1912.	0	3	0	0	2	3

2nd Ser. BOTANY.] [VOL. VII. PART 20.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

CONTENTS, TITLEPAGE, AND INDEX.

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

February 1913.

INDEX.

[NOTE.—Ordinal and Tribal Names are printed in SMALL CAPITALS; Accepted Names of Genera and Species in Roman; Synonyms in *Italic* type; an asterisk denotes first publication.]

Abies pectinata, *DC.*, fl.-whorls, 161; mentioned, 87.
Aceranthus, *Morr. & Decne.*, fl.-whorls, 157.
Achras Sapota, *Linn.*, seedl., 197, 195, 189.
Acrostichum aureum, *Linn.*, 423, 410.
  conforme, Sw., 422.
  ellipticum, Fée, 422.
  glabrescens, *Kuhn*, mentioned, 422.
  latifolium, Sw., 422.
  lineatum, *Kuhn*, mentioned, 422.
  neriifolium, *Wall.*, mentioned, 423.
  repandum, Baker, 414.
  repandum, Blume, 414.
  salicifolium, Willd., 423.
  simplex var. *martinicense*, Baker, 422.
  spathulatum, Bory, 423.
  spicatum, Linn. f., 420.
  sorbifolium, Baker, 418.
  tenuifolium, Baker, 418.
  viscosum, Baker, 423.
  —— var. *glabrescens*, Baker, 422.
Actiniopteris australis, *Link*, 419, 410.
  dichotoma, Metten., 419.
Adiantum caudatum, *Linn.*, 418, 410.
  caudatum (pars), Baker, 419.
  rhizophorum, *Sw.*, 419, 410.
Æluropus, *Trin.*, leaf-anat., 74.
Affinities of *Davidia involucrata*, Baill. (Horne), 303–326.
Agropyrum, *Gaertn.*, leaf-anat., 74.
AGROSTIDEÆ, leaf-anat., 74, 75.
Agrostis, *Linn.*, leaf-anat., 74.
  canina, *Linn.*, mentioned, 70.
Aira, *Linn.*, leaf-anat., 74–79.
  cæspitosa, *Linn.*, mentioned, 70.
  latifolia, *Hook.*, 79.
AIZOACEÆ, longitudinal symmetry, 287; mentioned, 267.
ALANGIACEÆ, mentioned, 319.
ALANGIEÆ, aff. to Davidia, *Baill.*, 322.
Alangium, *Lam.*, aff. to Davidia, *Baill.*, 319; ovary, 320; ovule, 321.
Alchornea latifolia, *Sw.*, mentioned, 2.
Aldabra Group, *see* Seychelles.
Algæ, calcareous, from the Indian Ocean, 93.
Alisma, *Linn.*, fl.-whorls, 156, 161.
Alnus, *Linn.*, mentioned, 42.
Alopecurus, *Linn.*, leaf-anat., 73.
  alpinus, *Sm.*, mentioned, 70.
  geniculatus, *Linn.*, mentioned, 70.
ALSINOIDEÆ, mentioned, 318.
Alsophila armata, *Presl*, mentioned, 2.
  aspera, *Spreng.*, mentioned, 2.
  parvula, *Jenm.*, mentioned, 2.
  pruinata, *Kaulf.*, mentioned, 2.
Altingia, *Noronha*, infl., 313.
AMARANTACEÆ, longitudinal symmetry, 288; mentioned, 267, 292.
Amaranthus, *Linn.*, internodes, 292, 302, 288.
  polygonoides, *Linn.*, 292, 302.
  retroflexus, *Linn.*, 292, 302.
AMENTACEÆ, mentioned, 42.
AMENTIFERÆ: Embryology of *Carpinus Betulus*, Linn. (Benson, Sanday & Berridge), 37–44.
Ammophila, *Host*, leaf-anat., 74.
Ampelodesma, *Beauv.*, leaf-anat., 74.
Amphicarpum, *Kunth*, leaf-anat., 74.
Amygdalus, *Linn.*, mentioned, 315.
ANACARDIACEÆ, anat., 130–132, 137, 138, 140.
Anadyomene Wrightii, *Harv.*, 168.
Ananas sativus, *Schult.*, fl.-whorls, 159.
Anatomy of *Enhalus acoroides*, Steud. (sphalm., "Zoll.") (Cunnington), 355–371; of the Julianiaceæ (Fritsch), 129–151; of the stem of *Lycopodium*, Linn. (Jones), 15–35; of Sapotaceous Seedlings (Smith), 189–200; of *Welwitschia mirabilis*, Hook. f. (Sykes), 327–354.
Andropogon, *Linn.*, leaf-anat., 73, 74, 81.
  Ischæmum, *Linn.*, 81.
ANDROPOGONEÆ, leaf-anat., 73–75.
Anemone, *Linn.*, fl.-whorls, 154, 156.
  Coronaria, *Linn.*, 156.
  Hepatica, *Linn.*, 154, 156.
  japonica, *Sieb. & Zucc.*, 154, 156.
  nemorosa, *Linn.*, 156.
  Pulsatilla, *Linn.*, 154, 156.
  ranunculoides, *Linn.*, 156.
Angiopteris evecta, *Hoffm.*, 424, 410.
Ankyropteris, *Bertrand*, mentioned, 380, 385.
  corrugata, *D. H. Scott*, compared with Botrychioxylon paradoxum, 384; leaf-trace, 377; stele, 376; mentioned, 373, 374, 381–384, 386.

3 T

Ankyropteris Grayi, *D. H. Scott*, mentioned, 377, 381, 384.
scandens, *Bertrand*, mentioned, 378.
Anomozamites subgroup, mentioned, 110.
Anthostema, *A. Juss.*, infl., 313.
Antrophyum callifolium, *Blume*, 420, 410.
immersum, *Metten.*, 420, 410.
reticulatum, Baker, 420.
reticulatum, *Kaulf.*, mentioned, 420.
Aralia, *Tourn.*, aff. to Davidia, *Baill.*, 319; ovary, 320; ovule, 315, 317, 321.
ARALIACEÆ, aff. to Davidia, *Baill.*, 322; ovules, 320; mentioned, 132, 315, 319.
Araucaria, *Juss.*, seedl., 333, 346, 350; transition, 340, 345, 349.
Bidwillii, *Hook. f.*, 333, 346, 350.
imbricata, *Pav.*, mentioned, 333 ftnote.
Arber, E. A. N., on *Psygmophyllum majus*, sp. nov., together with a revision of the genus, 391–407; on Triassic species of *Zamites* and *Pterophyllum*, 109–127.
Archæolithothamnion, *Fosl.*, mentioned, 101.
erythræum, *Fosl.*, 102, 95; mentioned, 101.
timorense, *Fosl.*, 102, 96; mentioned, 101.
Archæopteris obtusa, Lesq., 398.
Aristida, *Linn.*, leaf-anat., 74.
Aristolochia, *Tourn.*, mentioned, 375.
Arundinaria, *Michx.*, leaf-anat., 70–86; stam., 87.
aristata, *Gamble*, 82.
armata, *Gamble*, 82.
callosa, *Munro*, 82.
Clarkei, *Gamble*, 82.
densifolia, *Munro*, 82.
elegans, *Kurz*, 82.
falcata, *Nees*, 71, 73, 77, 82, 84.
Falconeri, *Benth. & Hook. f.*, 77, 78, 82.
Griffithiana, *Munro*, 82.
hirsuta, *Munro*, 82.
Hookeriana, *Munro*, 76, 77, 82, 84.
intermedia, *Munro*, 82, 84.
Arundinaria japonica, *Sieb. & Zucc.*, 70, 71, 79, 81, 84.
jaunsarensis, *Gamble*, 77, 82.
khasiana, *Munro*, 82.
Kumasasa, Hort. Kew, 71.
Ladingiva, [*Brandis*] nomen, 82.
Mannii, *Gamble*, 82.
microphylla, *Munro*, 82.
Prainii, *Gamble*, 82.
racemosa, *Munro*, 82.
Rolloana, *Gamble*, 82.
spathiflora, *Trin.*, 77, 82.
spp., 79, 81.
suberecta, *Munro*, 82.
Walkeriana, *Munro*, 82.
Wightiana, *Nees*, 82, 86.
Arundo, *Tourn.*, leaf-anat., 74.
Asimina, *Adans.*, fl.-whorls, 153.
ASPIDISTREÆ, mentioned, 159.
Aspidium *capense*, Willd., 414.
coriaceum, Sw., 414.
elatum, *Bojer*, mentioned, 413.
pleiotomum, *Kuhn*, 414, 410.
procerum, Bojer, 413.
strigosum, Willd., 412.
Asplenium affine, *Sw.*, 418, 410.
borbonicum, *Hook.*, mentioned, 417.
bulbiferum, *Forst.*, 418, 410.
caudatum, *Forst.*, 417, 410.
—— var. minor, *C. Chr.**, 417.
complanatum, *C. Chr.**, 416, 410.
cuneatum, *Lam.*, mentioned, 418.
—— var. *affine*, Baker, 418.
lineatum, *Sw.*, mentioned, 417.
lunulatum, *Sw.*, 416, 410.
nidus, *Linn.*, 416, 410.
obtusatum, *Forst.*, mentioned, 417.
pellucidum, *Lam.*, mentioned, 417.
resectum, Sm., 416.
sechellarum, Baker, 416.
spp., mentioned, 2.
tenerum, *Forst.*, 416, 410; mentioned, 417.
unilaterale, *Lam.*, 416, 410.
vivíparioides, *Kuhn*, mentioned, 418.
Asterochlæna, *Garcke*, mentioned, 380, 385.
Astragalus, *Linn.*, sp., 203 ftnote.
Atractocarpa, *Franch.*, sp., leaf-anat., 83.
Atragene, *Linn.*, fl.-whorls, 154.
Atriplex rosea, *Linn.*, internodes, 269–281, 300; mentioned, 282.
Aucuba, *Thunb.*, infl., 312; ovule, 316, 321.
japonica, *Thunb.*, 312.
Avena, *Linn.*, leaf-anat., 74.
AVENEÆ, leaf-anat., 74.
Avrainvillea amadelpha, *Gepp*, 178; mentioned, 164, 180.
comosa, G. Murr. & Boodle, 180.
Gardineri, *A. & E. S. Gepp**, 179; mentioned, 163.
lacerata, *J. Ag.*, mentioned, 179.
nigricans, *Decne.*, mentioned, 179.
Azorella, *Lam.*, mentioned, 219, 253.

Baiera, *F. Braun*, spp., mentioned, 401, 404.
Baillon, his views on the affinities of *Nyssa*, Gronov., and *Alangium*, Lam., criticised, 319–321.
Bamboo leaves, their structure (Brandis), 69–92.
Bambusa, *Schreb.*, leaf-anat., 73–87.
affinis, *Munro*, 83.
arundinacea, *Willd.*, 77, 86, 87.
Balcooa, *Roxb.*, 77.
burmanica, *Gamble*, 83.
khasiana, *Munro*, 77.
nutans, *Wall.*, mentioned, 84.
pallida, *Munro*, 83.
polymorpha, *Munro*, 86.
stricta, Roxb., 69.
Tulda, *Roxb.*, 77.
verticillata, Nees, 75.
verticillata, Willd., 75, 76.
vulgaris, Nees, 75.
vulgaris, *Schrad.*, 73, 75, 76, 80, 81.
BAMBUSEÆ, leaf-anat., 74; mentioned, 69.
Bambusium, *Heer*, mentioned, 124.
Imhoffi, *Heer*, 118.
Barberry, fl.-whorls, 157.
Bassia, *Koenig*, seedl., 197.
latifolia, *Roxb.*, 197, 189, 195.
longifolia, *Linn.*, 197, 189, 195.
Beech, mentioned, 87.

Benson, M., E. Sanday and E. Berridge, embryology of *Carpinus Betulus*, 37–44.
Benthamia, *Lindl.*, seed, 318.
Berberideæ, mentioned, 156.
Berberis, *Linn.*, fl.-whorls, 153, 157.
vulgaris, *Linn.*, mentioned, 204 ftnote.
Berridge, E., *see* Benson, M., E. Sanday and E. Berridge.
Betula, *Linn.*, mentioned, 37, 42.
Betulaceæ, mentioned, 43.
Betuleæ, mentioned, 43.
Boodlea coacta, *G. Murr. & De Toni*, 165.
van Bossei, *Reinb.*, 165; mentioned, 163, 164.
Boraginaceæ, mentioned, 268.
Bosse, Madame Weber van, on Caulerpaceæ from the Indian Ocean, 171.
Botrychioxylon, *D. H. Scott*, 373.
paradoxum, *D. H. Scott* *, 383; affinities, 384–386; aphlebiæ, 381; branching of stem, 382; compared with Ankyropteris corrugata, 384; general structure, 373; leaf-trace, 376–379; petiole, 379–381; roots, 381; stele, 374–376.
Botrychium, *Sw.*, stele, 376; mentioned, 373, 387.
Lunaria, *Sw.*, mentioned, 382.
ternatum, *Sw.*, mentioned, 376.
Botryopsis, *Miers*, fl.-whorls, 156.
Botryopterideæ, mentioned, 64, 373, 386 ftnote.
Brachypodium, *Beauv.*, leaf-anat., 74.
Brandis, Sir D., on the structure of Bamboo leaves, 69–92.
Brasenia, *Schreb.*, fl.-whorls, 153, 157.
Briza, *Linn.*, leaf-anat., 74.
Bromus, *Dill.*, leaf-anat., 74.
Bryopsis australis, *Sond.*, mentioned, 169, 170.
cæspitosa, Suhr, 169.
gemellipara, *J. Ag.*, mentioned, 170.
hypnoides, *Lamour.*, mentioned, 170.
indica, *A. & E. S. Gepp* *, 169; mentioned, 163, 170.
plumosa, *Ag.*, mentioned, 170.
Bryopsis sp., mentioned, 170.
Bryozoa, mentioned, 96.
Bumelia tenax, *Willd.*, seedl., 197, 189, 192–194, 198.

Cabomba, *Aubl.*, fl.-whorls, 153, 157.
Cactaceæ, mentioned, 154.
Calamagrostis, *Adans.*, leaf-anat., 74.
Calamopityeæ, mentioned, 385.
Calandrinia pilosiuscula, *DC.*, internodes, 299.
Calcareous algæ from the Indian Ocean, 93.
Calendula officinalis, *Linn.*, fl.-whorls, 161.
Calycanthaceæ, mentioned, 153, 154.
Calycanthus, *Linn.*, fl.-whorls, 154 and ftnote, 161.
Caprifoliaceæ, ovule, 322; seeds, 318; mentioned, 319.
Carpinus Betulus, *Linn.*, its embryology (Benson, Sanday & Berridge), 37–44; compared with Casuarina, 41–43; embryo-sacs, 38–41.
Caryophyllaceæ, longitudinal symmetry, 283; mentioned, 267, 268.
Castanea, *Tourn.*, mentioned, 38.
Casuarina, *Linn.*, compared with Carpinus, *Linn.*, 41–43; mentioned, 39.
glauca, *Sieber*, mentioned, 41.
Rumphiana, *Miq.*, mentioned, 41.
stricta, *Ait.*, mentioned, 41.
suberosa, *Otto & Dietr.*, mentioned, 41.
Catabrosa, *Beauv.*, leaf-anat., 74.
Caulerpa, *Lamour.*, mentioned, 163, 164.
crassifolia, *J. Ag.*, f. typica, *Web. v. Bosse*, 171.
cupressoides, *Web. v. Bosse*, 171.
—— var. typica f. denudata, *Web. v. Bosse* *, 172.
—— var. typica f. Gardineri, *Web. v. Bosse* *, 172.
—— var. mamillosa f. nuda, *Web. v. Bosse*, 173; mentioned, 172.
Freycinetii, *Ag.*, var. typica, *Web. v. Bosse*, 171.
Caulerpa Freycinetii var. typica f. lata, *Web. v. Bosse*, 171.
—— var. typica f. spiralis, *Web. v. Bosse*, 171.
Lessonii, *Bory*, mentioned, 172.
pinnata f. *typica*, Web. v. Bosse, 171.
taxifolia, *J. Ag.*, f. interrupta, *Sved.*, 171.
—— f. asplenioides, *Web. v. Bosse*, 171.
Caulerpaceæ of the Ind. Ocean, 171.
Celastrineæ, mentioned, 132.
Cenchrus, *Linn.*, leaf-anat., 74.
Centrospermæ, Longitudinal Symmetry (Groom), 267–302.
Cephalostachyum, *Munro*, leaf-anat., 71–83.
capitatum, *Munro*, 71, 81, 83.
latifolium, *Munro*, 83.
pallidum, *Munro*, 71, 73, 81, 83.
Cerastium arvense, *Linn.*, internodes, 283, 286, 301.
Cerasus, *Linn.*, sp., mentioned, 303.
Ceratopteris thalictroides, *Brongn.*, 423, 410.
Ceratozamia, *Brongn.*, mentioned, 117, 198.
Ceropteris calomelanos, *Underw.*, 418; mentioned, 409.
Chenopodiaceæ, longitudinal symmetry, 269; mentioned, 267, 268, 283.
Chenopodium Bonus-Henricus, *Linn.*, internodes, 282, 301, 269.
sp., mentioned, 283.
Chimonantheæ, mentioned, 154.
Chimonanthus, *Lindl.*, fl.-whorls, 154.
Chlorideæ, leaf-anat., 74, 75.
Chloris, *Sw.*, leaf-anat., 74.
Chlorodesmis comosa, *Baill. & Harv.*, 180.
Chlorophyceæ of the 'Sealark' Expedition (A. & E. S. Gepp), 163–182.
Christensen, C., Ferns of the Seychelles and the Aldabra Group, 409–425.
Chrysanthemum Leucanthemum, *Linn.*, fl.-whorls, 161, 162.
Chrysodium bipinnatifidum, Metten., 414.

Chrysophyllum, *Linn.*, seedl., 197.
Cainito, *Linn.*, 195–198, 189.
olivæforme, *Linn.*, 197, 189, 196.
Roxburghii, *G. Don*, 197, 189, 196.
Chuchiraga insignis, *Humb. & Bonpl.*, mentioned, 234.
Chusquea pinifolia, *Nees*, leaf-anat., 72, 77, 78.
Quila, *Kunth*, leaf-anat., 83.
Cladocephalus excentricus, *A. & E. S. Gepp**, 177 ; mentioned, 163.
luteo-fusca, *Börgesen*, mentioned, 178.
scoparius, *Howe*, mentioned, 177.
Cladophora, *Kuetz.*, spp., 165.
CLADOPHORACEÆ of the Indian Ocean, 165.
CLADOXYLEÆ, mentioned, 64.
Cladoxylon, *Unger*, mentioned, 386.
Clematis, *Dill.*, fl.-whorls, 154.
Clepsydropsis, *Unger*, mentioned, 380.
Clethra Alexandri, *Griseb.*, mentioned, 2.
tinifolia, *Sw.*, mentioned, 2.
Cocculus, *DC.*, fl.-whorls, 153.
CODIACEÆ of the Ind. Ocean, 173.
Codium, *Stackh.*, 173.
adhærens, *Ag.*, 173.
difforme, *Kuetz.*, 173; mentioned, 163.
elongatum, *Ag.*, 173.
ovale, *Zanard.*, 173.
tomentosum, *Stackh.*, 173, 17 .
CŒNOPTERIDEÆ, mentioned, 386.
Coix, *Linn.*, leaf-anat., 74.
Colpoxylon, *Brongn.*, mentioned, 63.
COMBRETACEÆ, aff. to Davidia, *Baill.*, 319 ; mentioned, 303.
CONIFERÆ, mentioned, 18, 132.
CONIFERALES, mentioned, 404, 405.
Convolvulus Scammonia, *Linn.*, mentioned, 341 ftnote.
CORALLINACEÆ of the Indian Ocean, 98–108.
CORDAITALES, mentioned, 124.
Cordaites, Compter, 112.
Cordaites, *Unger*, 118 ; mentioned, 123–125.
keuperianus, *Compter*, 116.
spp., mentioned, 402, 403.
CORNACEÆ, aff. to Davidia, 322 ; mentioned, 304, 307, 315, 319.
CORNOIDEÆ, ovules, 321 ; mentioned, 322.
Cornus, *Linn.*, infl., 312, 314 ; ovule, 316, 321 ; seed, 318 ; mentioned, 306.
Mas, *Linn.*, 314.
sanguinea, *Linn.*, 312, 314.
CORYLEÆ, mentioned, 43.
Corylopsis spicata, *Sieb. & Zucc.*, infl., 313, 314.
Corylus, *Linn.*, mentioned, 37, 38.
sp., mentioned, 303.
Coscinium, *Colebr.*, fl.-whorls, 156.
Cowslip, fl.-whorls, 161.
Crocus, *Linn.*, sp., mentioned, 241.
Crypsis, *Ait.*, leaf-anat., 73.
Ctenium, *Panz.*, leaf-anat., 74.
Culcitium, *Humb. & Bonpl.*, mentioned, 234.
Cunnington, Hilda M., Anatomy of *Enhalus acoroides*, Steud. (sphalm., "Zoll."), 355–371.
CUPRESSINEÆ, mentioned, 347 ftnote.
CUPULIFERÆ, anat., 130–132.
Cyathea concinna, *Jenm.*, mentioned, 2.
elegans, *Hew.*, mentioned, 2.
pubescens, *Metten.*, mentioned, 2.
sechellarum, *Metten.*, 412, 410.
CYATHEACEÆ of the Seychelles, 412.
Cyathotrachus altus, *D. M. S. Wats.*, mentioned, 45.
CYCADACEÆ, mentioned, 343 ftnote.
Cycadean foliar bundles, mentioned, 385 ; frond, mentioned, 117.
Cycadella sp., mentioned, 338, 343 ftnotes.
Cycadites, *Sternb.*, mentioned, 110.
taxodinus, *Goepp.*, mentioned, 110.
CYCADOFILICES, mentioned, 63.
Cycadophyta, types of fronds belonging to the (Arber), 109–127 ; mentioned, 404, 405.
Cycads, mentioned, 117, 124, 125, 345, 346, 379, 338 ftnote ; seedl., mentioned, 350.
Cycas siamensis, *Miq.*, mentioned, 346.
CYCLANTHEÆ, mentioned, 159.
Cyclophorus spissus, *Desv.*, 421, 410.
Cyclopteris *Brownii*, Dawson, 398.
gigantea, *Kutorga*, mentioned, 401.
Cyclopteris *obtusa*, Dawson, 398.
sp., mentioned, 399.
Cymodocea, *Koenig*, mentioned, 95 ftnote.
ciliata, *Ehrenb.*, 186.
isoetifolia, *Aschers.*, 186.
serrulata, *Aschers. & Magn.*, 186.
Cynodon Dactylon, *Pers.*, leaf-anat., 72, 80.
Cynosurus, *Linn.*, leaf-anat., 74.
Czekanowskia, *Heer*, mentioned, 404.

Dactylis, *Linn.*, leaf-anat., 74.
glomerata, *Linn.*, mentioned, 84.
Danthonia, *DC.*, leaf-anat., 74.
Darea Belangeri, Bory, 417.
bifida, Bory, 417.
Davallia chærophylloides, *Steud.*, 415, 410.
denticulata, *Metten.*, mentioned, 415.
—— var. *intermedia*, Metten., 415.
elata, Baker, 415.
Hornei, Baker, 416.
pedata, Sw., 415.
speluncæ, Baker, 415.
tenuifolia, Sw., 415.
Davidia, *Baill.*, 303, 323.
involucrata, *Baill.*, its Structure and Affinities (Horne), 303–326 ; affinities, 319–323 ; gen. anat., 305–307 ; inflorescence, 307–309, 312–314 ; ovary, 310–311, 315–319.
tibetana, David, 303.
DAVIDIOIDEÆ, mentioned, 304.
Dendrocalamus, *Nees*, leaf-anat., 69–86.
Brandisii, *Kurz*, 73.
giganteus, *Munro*, 70, 72, 73, 75, 77, 79, 80.
Hamiltonii, *Nees & Arn.*, 77–81 ; mentioned, 84.
latiflorus, *Munro*, 83.
longispathus, *Kurz*, 77.
strictus, *Nees*, 69–72, 78–80, 83, 86.
Diandrolyra, *Stapf*, leaf-anat., 70, 74, 88.
bicolor, *Stapf*, 70, 88.
Dichopsis petiolaris, Thw., 194.

Dicranophyllum, *Grand'Eury*, mentioned, 404, 405.
sp., mentioned, 403.
Dictyosphæria favulosa, *Decne.*, 168.
Versluysii, *Web. v. Bosse*, 168.
Dictyota dichotoma, *Lamour.*, 186.
Digraphis, *Trin.*, leaf-anat., 73.
DILLENIACEÆ, mentioned, 153.
Dineuron, *Ren.*, mentioned, 378, 380.
pteroides, *Ren.*, mentioned, 379.
Dinochloa, *Buese*, leaf-anat., 70; seed, 87.
andamanica, *Kurz*, 70, 73, 75–77, 79, 81.
Macclellandii, *Kurz*, 70, 88.
Dioonites, *Bornem.*, mentioned, 110.
Diospyros, *Linn.*, mentioned, 193, 197, 198.
Diphylleia, *Michx.*, fl.-whorls, 157.
Diplachne, *Beauv.*, leaf-anat., 74.
Diplazium polypodioides, *Blume*, 416.
sechellarum, *C. Chr.*, 416, 410.
Diplolabis, *Ren.*, pet., 380; mentioned, 385.
Römeri, *Gordon*, mentioned, 374, 380, 383.
Dipterocarpus tuberculatus, *Roxb.*, mentioned, 87.
Distichlis, *Rafin.*, leaf-anat., 74.
Di-trimerous whorls among the flowers of dicotyledons, their origin (Henslow), 153–162.
Dobinea, *Buch.-Ham.*, spp., mentioned, 131, 135.
Double Chinese Cherry, 313 ftnote.
Dryopteris chrysotricha, *C. Chr.*, 414.
cucullata, *Christ*, 413, 410.
effusa, *Urb.*, mentioned, 413.
Hornei, *O. Kuntze*, 414, 410.
mauritiana, *C. Chr.*, 413, 410.
—— var. Gardineri, *C. Chr.**, 413.
mollis, *Hieron.*, mentioned, 413.
parasitica, *O. Kuntze*, 413, 410.
strigosa, *C. Chr.*, 412, 410.
tomentosa, *Thouars*, mentioned, 412.
unita, O. Kuntze, 413.
Wardii, *O. Kuntze*, 413, 410.

Ectocarpus spongiosus, *Dickie*, 186.
Elæagnus, *Linn.*, mentioned, 205.
Elaphoglossum callifolium, *T. Moore*, mentioned, 422.
Elaphoglossum conforme, *Schott*, 422, 410.
flaccidum, *T. Moore*, mentioned, 423.
Hornei, *C. Chr.**, 422, 410.
latifolium, *J. Sm.*, 422, 410.
martinicense, *T. Moore*, 422, 410.
—— var. obtusum, *C. Chr.**, 422.
petiolatum, *Urb.*, 423, 410.
—— var. salicifolium, *C. Chr.*, 423.
Sieberi, *Hook. & Grev.*, mentioned, 422.
simplex, *Schott*, mentioned, 422.
spathulatum, *T. Moore*, 423, 410.
Elder, fl.-whorls, 159.
Eleusine, *Gaertn.*, leaf-anat., 74.
Elionurus, *Humb. & Bonpl.*, leaf-anat., 73.
Elymus, *Linn.*, leaf-anat., 74.
Embryology of *Carpinus Betulus*, Linn. (Benson, Sanday and Berridge), 37–44.
Encephalartos Barteri, *Carruth.*, mentioned, 346.
Enhalus, *Rich.*, 355.
acoroides, *Steud.*, 187; its anatomy (Cunnington), 355–371; bracts, 365; inflorescences, 364–367; leaf, 359; rhizome, 356; root, 363.
Epidendrum cochlearifolium, Sw., 9.
ovale, Sw., 10.
pulchellum, Sw., 7.
tridentatum, Sw., 6.
Epilobium, *Dill.*, spp., fl.-whorls, 161.
Epimedium, *Linn.*, fl.-whorls, 157.
Epiphyllum, *Haw.*, fl.-whorls, 154, 161.
Eragrostis, *Host*, leaf-anat., 74.
Ercilla spicata, *Moq.*, internodes, 299, 302.
Eremopteris, *Schimp.*, sp., mentioned, 402.
Erianthus, *Michx.*, leaf-anat., 74.
Espeletia grandiflora, *Humb. & Bonpl.*, mentioned, 234.
Etapteris, *Bertrand*, pet., 380.
Scottii, *Bertrand*, 380.
Eugenia fragrans, *Willd.*, mentioned, 2.
Euginkgophyllum, *Arber**, suggested new genus, 404 ftnote.
Euphorbia, *Linn.*, infl., 313.
EUPHORBIACEÆ, mentioned, 304, 313.
Eustigma oblongifolium, *Gardn. & Champ.*, ovule, 321.

Fagopyrum, *Tourn.*, fl.-whorls, 158.
Fagus, *Linn.*, mentioned, 42, 190.
sylvatica, *Linn.*, mentioned, 87, 305.
Farmer, J. B., communication by (Horne), 303.
Fawcett, W., and A. B. Rendle, Jamaican species of *Lepanthes*, 1–13.
Ferns of the Seychelles and the Aldabra Group (Christensen), 409–425; distribution, 410; mentioned, 404.
Festuca, *Linn.*, leaf-anat., 74.
FESTUCEÆ, leaf-anat., 74, 75.
Flabellaria luteo-fusca, Crouan, 177, 178.
Foraminifera, crust-like, mentioned, 95, 96, 99.
Foslie, M., Lithothamnia of the Sladen Trust Expedition, 93–108.
Fothergilla, *Murr.*, infl., 313; mentioned, 304.
alnifolia, *Linn.*, ovule, 321.
Fritsch, F. E., anatomy of the Julianiaceæ, 129–151.
Froelichia gracilis, *Moq.*, internodes, 291, 302, 288.
FUCACEÆ of the Ind. Ocean, 182.

GALIEÆ, ovule, 322.
Gardiner, J. S., calcareous algæ collected by, 93; communications by, (Foslie) 93, (Christensen) 409; ferns collected by, 409–425; marine algæ and phanerogams collected by, 163–188.
Garrya, *Dougl.*, infl., 312, 313; mentioned, 307.
Thuretii, *Carr.*, 313.
Gaudinia, *Beauv.*, leaf-anat., 74.
Gepp, A., and E. S. Gepp, Marine Algæ and Phanerogams of the 'Sealark' Expedition, 163–188.
Geranium, *Linn.*, fl.-whorls, 158 ftnote.

Gigantochloa, *Kurz*, stam., 87.
verticillata, *Munro*, leaf-anat., 76.
Ginkgo, *Linn.*, mentioned, 396, 402, 404.
biloba, *Linn.*, mentioned, 404.
digitata, *Brongn.*, mentioned, 404.
GINKGOALES, mentioned, 404, 405.
Ginkgophyllum, *Sap.*, mentioned, 403, 404.
flabellatum, Ren., 394, 397.
Grasseti, *Sap.*, 402.
minus, *Sandb.*, 402.
Gleichenia, *Sm.*, mentioned, 25, 32.
dichotoma, Baker, 424.
linearis, *C. B. Clarke*, 424, 410.
GLEICHENIACEÆ of the Seychelles, 424.
Glossopteris, *O. Feistm.*, flora so-called, mentioned, 110, 118, 400.
sp., mentioned, 393, 396.
Glyceria, *R. Br.*, leaf-anat., 71, 74.
aquatica, *Wahlenb.*, 71.
Gomphrena, *Linn.*, mentioned, 291.
decumbens, *Jacq.*, internodes, 288, 301.
globosa, *Linn.*, internodes, 290, 302.
Goniolithon Fosliei, *Heydr.*, 97.
frutescens, *Fosl.*, 102, 94–98; mentioned, 107.
—— f. congesta, mentioned, 103.
—— f. flabelliformis, mentioned, 103.
—— f. subtilis, mentioned, 103.
myriocarpon, *Fosl.*, 97.
Groom, P., Longitudinal Symmetry of the Centrospermæ, 267–302; communication by (Cunnington), 355.
Gunnera, *Linn.*, ovule, 322.
GUTTIFERÆ, mentioned, 132.
Gymnosorus, *J. Ag.*, 185.
variegatus, J. Ag., 184.
Gynerium, *Humb. & Bonpl.*, leaf-anat., 74.
argenteum, *Nees*, mentioned, 84.
Gypsina, *Carter*, sp., mentioned, 96 ftnote.
Halimeda, *Lamour.*, mentioned, 95.
cuneata, *Hering*, f. undulata, *E. S. Bart.*, 181.
gracilis, *Harv.*, f. typica, *E. S. Bart.*, 181.
incrassata, *Lamour.*, f. typica, *E. S. Bart.*, 181.
—— f. monilis, *E. S. Bart.*, 181.
—— f. ovata, *J. Ag.*, 181.
macroloba, *Decne.*, 182.
Opuntia, *Lamour.*, f. cordata, *E. S. Bart.*, 181.
—— f. triloba, *E. S. Bart.*, 181.
—— f. typica, *E. S. Bart.*, 181.
Tuna, *Lamour.*, f. platydisca, *E. S. Bart.*, 181.
—— f. typica, *E. S. Bart.*, 180.
Haliseris Woodwardia, *J. Ag.*, 185.
Halophila, *Thouars*, mentioned, 355.
ovalis, *Hook. f.*, 187.
HAMAMELIDACEÆ, ovules, 321; mentioned, 304, 313.
Hamamelis, *Gronov.*, ovule, 321.
Hedera, *Tourn.*, fl.-whorls, 158, 161; infl., 314; ovules, 321.
Helix, *Linn.*, 158, 161.
—— var. arborea, hort. = arborescens, *Todd*, 314.
Helianthus annuus, *Linn.*, fl.-whorls, 161.
tuberosus, *Linn.*, mentioned, 153 ftnote, 161.
Henslow, G., origin of di-trimerous whorls among the flowers of dicotyledons, 153–162.
Heterangium, *Corda*, mentioned, 48, 56, 63, 64.
Grievii, *Will.*, mentioned, 56.
tiliæoides, *Will.*, mentioned, 57.
Hierochloa, *Beauv.*, leaf-anat., 73.
Hill, A. W., revision of the genus *Nototriche*, Turcz., 201–266.
HIPPOCRATEACEÆ, mentioned, 132.
Histiopteris incisa, *J. Sm.*, 419, 410.
Holcus, *Linn.*, leaf-anat., 74.
HORDEÆ, leaf-anat., 74.
Hordeum, *Linn.*, leaf-anat., 74.
Horne, A. S., Structure and Affinities of *Davidia involucrata*, Baill., 303–326.
Humata repens, *Diels*, 415.
HYDROCHARIDACEÆ of the Ind. Ocean, 187; mentioned, 335.
Hydrocharis, *Linn.*, fl.-whorls, 161.
Hymenolepis spicata, *Presl*, 420, 410.
HYMENOPHYLLACEÆ of the Seychelles, 411.
Hymenophyllum Blumeanum, *Spreng.*, mentioned, 412.
ciliatum, *Sw.*, 412, 410.
hygrometricum, *Desv.*, 412, 410.
polyanthos, *Sw.*, 412, 410.
spp., mentioned, 2.
HYPERICINEÆ, mentioned, 132.

Illipe latifolia, F. Muell., 195.
Malabarorum, Engl., 195.
Imbricaria coriacea, *A. DC.*, seedl., 197, 189, 190.
Imperata, *Cyrilli*, leaf-anat., 74.
Indian Ocean, Lithothamnia from the, 93.
Ischæmum petiolare, *Hack.*, leaf-anat., 81.
Ivy, fl.-whorls, 158, 161.

Jamaican Species of *Lepanthes* (Fawcett & Rendle), 1–13.
Jeffersonia, *Bart.*, fl.-whorls, 157.
Jerusalem Artichoke, fl.-whorls, 153, 161.
Jones, C. E., Morphology and Anatomy of the Stem of *Lycopodium*, 15–35.
JUGLANDACEÆ, mentioned, 130, 131.
Juliania, *Schlecht.*, anat., 150, 133–148.
adstringens, *Schlecht.*, 150, 134–140, 143, 146.
amplifolia, *Hemsl.*, 150, 134–137, 141, 145, 146.
glauca, *Hemsl. & Rose*, 150, 133, 134, 137, 141, 148.
mollis, *Hemsl.*, 150, 133–137, 142.
JULIANIACEÆ, anatomy considered from a systematic point of view (Fritsch), 129–151; anat. compared with the Anacardiaceæ, 132;

anat. of female infl., 143; anat. diagnosis, 149–151; embryo-anat., 149; fruit-anat., 144–149; leaf-anat., 133–141; stem-anat., 141–143.

Koeleria, *Pers.*, leaf-anat., 74.
Krannera mirabilis, *Velen.*, 116.

Lagerstrœmia, *Linn.*, fl.-whorls, 158.
Lagurus, *Linn.*, leaf-anat., 74.
Lardizabala, *Ruiz & Pav.*, fl.-whorls, 153, 156.
Laurel, fl.-whorls, 158, 161.
Leersia, *Soland.*, leaf-anat., 74.
LEGUMINOSÆ, mentioned, 347 ftnote.
LEITNERIEÆ, mentioned, 130 ftnote.
Lepantes, 4, sphalm.,=seq.
Lepanthes, *Sw.*, an Account of the Jamaican Species (Fawcett & Rendle), 1–13; clavis, 4; compared with Pleurothallis, 2; derivation of the name, 3; distribution, 1.
bilabiata, *Fawcett & Rendle**, 4, 2, 3.
cochlearifolia, *Sw.*, 9, 4.
concinna, *Sw.*, 10, 4; mentioned, 11.
—— var. obtusipetala, *Fawcett & Rendle**, 11.
concolor, *Fawcett & Rendle**, 3–5.
divaricata, *Fawcett & Rendle**, 11, 3, 4.
—— var. minor, *Fawcett & Rendle**, 12.
Loddigesiana, *Reichenb. f.*, 8, 4.
obtusa, *Fawcett & Rendle**, 11, 3, 4.
pulchella, *Sw.*, 7, 4; mentioned, 8.
quadrata, *Fawcett & Rendle**, 7, 3, 4.
rotundata, *Griseb.*, 6, 4.
sanguinea, *Hook.*, 9, 3, 4.
tridentata, Lindl., 8.
tridentata, *Sw.*, 6, 3, 4; mentioned, 8, 11.
Lepidotis, *Sw.*, subgenus, mentioned, 32.
Leptaspis, *R. Br.*, leaf-anat., 74, 81, 88.
conchifera, *Hack.*, 81.
urceolata, *R. Br.*, 88.

Leptochilus bipinnatifidus, *C. Chr.**, 414, 410.
cuspidatus, *C. Chr.*, mentioned, 414.
Lepturus, *R. Br.*, leaf-anat., 74.
Leycesteria, *Wall.*, ovary, 319.
LILIACEÆ, mentioned, 115.
Lilium, *Tourn.*, mentioned, 37.
Martagon, *Linn.*, mentioned, 41.
speciosum, *Thunb.*, fl.-whorls, 159.
Lindsaya *chinensis*, Metten., 415.
ensifolia, Sw., 415.
Hornei, *C. Chr.*, 416, 410.
Kirkii, *Hook.*, 416, 410.
Pervillei, Metten., 416.
Lithophyllum, *Phil.*, 103.
affine, Fosl., 97, 104.
craspedium, *Fosl.*, 105, 107, 94–98.
—— f. abbreviata, *Fosl.*, mentioned, 105, 107.
—— f. compressa, *Fosl.*, mentioned, 105.
—— f. subtilis, *Fosl.*, mentioned, 107.
Gardineri, *Fosl.**, 106, 105, 93–97, 103.
—— f. obpyramidata, *Fosl.**, 106.
—— f. subhemisphærica, *Fosl.**, 106.
—— f. typica, *Fosl.**, mentioned, 107.
Kaiserii (pars), Heydr., 104.
Kaiserii, *Heydr.*, 104, 96; mentioned, 106.
—— (pallescens), 94, 97.
—— f. subplicata, *Fosl.*, 104.
—— f. typica, *Fosl.*, 104.
madagascarense, Heydr., 104.
moluccense, *Fosl.*, 104, 96.
—— f. pygmæa, *Fosl.*, mentioned, 104.
—— f. flabelliformis, *Fosl.*, mentioned, 104.
pallescens, *Fosl.*, 104.
Okamurai, *Fosl.*, 103, mentioned, 102.
—— f. ptychoides, *Fosl.*, 103, 95.
—— f. trincomaliensis, *Fosl.*, mentioned, 103.
onkodes, *Heydr.*, 105, 94–98; mentioned, 107.

Lithophyllum Racemus, *Fosl.*, mentioned, 104.
—— f. typica, *Fosl.*, mentioned, 101.
Yendoi f. mahëica, *Fosl.*, 97.
Lithothamnia of the Sladen Trust Expedition (Foslie), 93–108; distrib. in the Ind. Ocean, 93–98.
Lithothamnion australe, *Fosl.*, 101, 94–97; mentioned, 100.
—— f. brachiata, *Fosl.*, mentioned, 102.
—— f. minutula, *Fosl.*, mentioned, 101.
—— f. tualensis, *Fosl.*, mentioned, 101.
brachycladum, *Fosl.*, mentioned, 101.
coralloides, Crouan, f. *australis*, Fosl., 101.
erythræum, Rothpl., 102.
floridanum, *Fosl.*, mentioned, 101.
fruticulosum, *Fosl.*, 99–101.
—— f. *crassiuscula*, Fosl., 99.
—— f. *clavulata*, Fosl., 99.
funafutiense f. *purpurascens*, Fosl., 98.
gibbosum, *Fosl.*, 100, 95; mentioned, 93, 102.
—— f. crassa, *Fosl.*, 100.
—— f. parvula, *Fosl.*, 100.
indicum, *Fosl.*, 99, 94–97; mentioned, 101.
—— f. subtilis, *Fosl.*, 99.
—— f. typica, *Fosl.*, 99.
Kaiserii, Heydr., 104.
onkodes, Heydr., 105.
purpurascens, *Fosl.*, 98, 96.
simulans, *Fosl.*, 94, 97.
sp., mentioned, 94.
validum, *Fosl.*, mentioned, 101.
LITHOTHAMNIONEÆ of the Indian Ocean, 98–102.
Lolium, *Linn.*, leaf-anat., 74.
Lomariopsis Pervillei, Metten., 418.
Lonchitis *hirsuta*, Kuhn, 420.
pubescens, *Willd.*, 420, 410.
Longitudinal Symmetry of the Centrospermæ (Groom), 267–302.
Lonicera, *Linn.*, ovaries, 319.
Caprifolium, *Linn.*, 319.
Lychnis, *Linn.*, internodes, 283–285.
dioica, *Linn.*, 285.
diurna, *Sibth.*, 284, 301.
vespertina, *Sibth.*, mentioned, 285.

Lycopodium, *Linn.*, Morphology and Anatomy of its stem (Jones), 15–35; apex, 29; branching, 29–31; classification, 31–33; roots, 29.
alopecuroides, *Linn.*, mentioned, 22.
alpinum, *Linn.*, 20, 29, 31; mentioned, 15, 23.
annotinum, *Linn.*, 19; mentioned, 15, 22.
cernuum, *Linn.*, 25, 28, 31; mentioned, 17, 21, 32.
Chamæcyparissus, *A. Br.*, 20.
clavatum, *Linn.*, 17, 25, 28–31; mentioned, 15, 19–21, 27, 32.
complanatum, *Linn.*, 20, 29–31; mentioned, 32.
Dalbousieanum, *Spring*, 24; mentioned, 23, 32.
dichotomum, *Jacq.*, 25.
Drummondii, *Spring*, mentioned, 22.
inundatum, *Linn.*, 21, 29, 31; mentioned, 15, 16, 27, 32.
linifolium, *Linn.*, 25.
nummularifolium, *Blume*, 24; mentioned, 23, 25, 32.
obscurum, *Linn.*, 21; mentioned, 32.
Phlegmaria, *Linn.*, 24; mentioned, 23, 32.
reflexum, *Lam.*, 23.
salakense, *Treub*, 28; mentioned, 17, 25, 32.
Selago, *Linn.*, 22, 27, 28, 31; mentioned, 15, 16, 32.
serratum, *Thunb.*, 22, 27, 28.
strictum, *Baker*, 25; mentioned, 32.
squarrosum, *Frost*, 23, 28, 31; mentioned, 24, 25, 32.
taxifolium, *Sw.*, mentioned, 32.
tetragonum, *Hook.*, 23.
uliginosum, *Labill.*, 23.
volubile, *Frost*, 23; mentioned, 17.
Lyginodendreæ, mentioned, 64, 385.
Lyginodendron, *Will.*, mentioned, 64.
Lygodium pinnatifidum, *Sw.*, mentioned, 59.
spp., 48, 59.
Lythrarieæ, mentioned, 154.
Lythrum Salicaria, *Linn.*, fl.-whorls, 158.
spp., 158.

Macropterygium (pars), Schimp., 111, 121, 123.
Bronnii, Schimp., 120.
Schenkii, Schimp., 113, 117.
Macrozamia, *Miq.*, mentioned, 346 ftnote.
Magnolia, *Linn.*, fl.-whorls, 153, 156, 157, 161.
grandiflora, *Linn.*, 157.
Mahonia, *Nutt.*, fl.-whorls, 157.
Malva, *Linn.*, mentioned, 201.
pygmæa, Wedd., 218.
Malvaceæ, two groups of, 201.
Malvastrum, *A. Gray*, 201; compared with Nototriche, *Turcz.*, 205, 206.
anthemidifolium, A. Gray, 254.
—— var., mentioned, 250.
aretioides, A. Gray, 231.
auricomum, Phil., 220.
borussicum, Wedd., 236, 239.
Castelnæanum, Wedd., 257.
Cavanillesii, *A. Gray* (sp. dub.), 217, 260; mentioned, 233.
Cavanillesii (pars), A. Gray, 260.
clandestinum, Bak. fil., 219.
compactum, A. Gray, 221.
condensatum, Bak. fil., 223, 224.
Copelandii, Hieron., 238, 240.
flabellatum, Wedd., 222.
Lobbii, Bak. fil., 229.
longirostre, Wedd., 252.
lobulatum, Wedd., 225.
Macleanii, A. Gray, 230.
Mandonianum, Wedd., 253; mentioned, 249.
megalorrhizum, Bak. fil., 260.
Meyeni, Solms, 239, 242; mentioned, 237.
nubigena, *Bak. fil.*, 201 ftnote.
obcuneatum, Bak. fil., 225, 227.
Orbignyanum, Bak. fil., 238.
Orbignyanum, Wedd., 238.
oriastrum, *Bak. fil.*, mentioned, 201 ftnote.
parviflorum, Phil., 239.
Pearcei, Bak. fil., 249, 256.
pediculariæfolium, Bak. fil., 245, 248.
Malvastrum *pediculariæfolium*, A. Gray, 223, 247.
pediculariæfolium var. *rugosum*, Phil., 245.
phyllanthos (pars), Wedd., 224, 232, 237.
phyllanthos (pars), A. Gray, 222, 223.
pichinchense, A. Gray, 231, 232.
—— (forma), *Hieron.*, 232.
pinnatum, Bak. fil., 248.
pinnatum, *A. Gray*, mentioned, 233, 259.
pygmæum, A. Gray, 218.
rugosum, Phil., 245.
sajamense, Hieron., 225, 239, 242, 243.
saltense, Hieron., 256.
saltense, K. Schum., 254.
sp. nov.?, mentioned, 250.
stenopetalum, A. Gray, 251.
stipulare, *Phil.* (sp. dub.), 217, 260.
ulophyllum, A. Gray, 224.
ulophyllum, Hieron., 246.
ulophyllum, Wedd., 224, 246.
Malveopsis, Presl, 201.
pichinchensis, O. Kuntze, var. *decolorans*, O. Kuntze (var. dub.), 260; mentioned, 232.
saltensis, O. Kuntze, 256.
Marattia fraxinea, *Sm.*, 424, 410.
Marattiaceæ, mentioned, 59, 60; of the Seychelles, 424.
Marigold, fl.-whorls, 161.
Marine Algæ and Phanerogams of the 'Sealark' Expedition (A. & E. S. Gepp), 163–188.
Marlea, *Roxb.*, mentioned, 319.
Masdevallia, *Ruiz & Pav.*, mentioned, 3.
Maydeæ, leaf-anat., 74, 75.
Medullosa, *Cotta*, mentioned, 57, 64.
anglica, *D. H. Scott*, 48, 53–55; mentioned, 47, 49, 59, 64.
Leuckarti, *Solms*, mentioned, 64.
sp., mentioned, 46.
Solmsii, *Schenk*, mentioned, 348.
stellata, *Cotta*, mentioned, 348.
—— var. gigantea [*Sykes*], mentioned, 348.

Medulloseæ, stele, 48 ftnote, 54; mentioned, 63, 64, 348.
Megaloxylon, *Sew.*, mentioned, 48, 56.
sp., mentioned, 55, 64.
Melica, *Linn.*, leaf-anat., 74.
Melobesieæ of the Indian Ocean, 102–108.
Melocalamus, *Benth.*, seed, 87.
Melocanna, *Trin.*, seed, 87.
bambusoides, *Trin.*, leaf-anat., 71–73, 76–81, 83–87.
Menispermeæ, mentioned, 156.
Mesembryanthemum, *Dill.*, internodes, 287, 301.
echinatum, *Lam.*, 287, 301.
filamentosum, *Linn.*, 287, 301.
Mesoxylon, *D. H. Scott & Maslen*, mentioned, 385.
Metaclepsydropsis, *Bertrand*, pet., 380; mentioned, 385, 387.
duplex, *Bertrand*, 383, 384; mentioned, 374, 378.
Mibora, *Adans.*, leaf-anat., 74.
Microdictyon, *Decne.*, mentioned, 164.
calodictyon, *Decne.*, mentioned, 166.
pseudohapteron, *A. & E. S. Gepp* *, 165, 163.
umbilicatum, *Zanard.*, mentioned, 166.
spp., mentioned, 167.
Microlepia speluncæ, *T. Moore*, 415, 410.
Milium, *Linn.*, leaf-anat., 74.
Mimusopeæ, mentioned, 190.
Mimusops, *Linn.*, seedl., 189–197.
Elengi, *Linn.*, 195–197.
Kauki, *Linn.*, 197, 189, 190, 195.
Schimperi, *Hochst.*, 197, 189, 190, 196.
Molinia, *Schrank*, leaf-anat., 74.
Monocotyledons, their existence in Triassic epochs unlikely, 111, 124.
Monogramma graminea, *Schkuhr*, 420, 410.
Morphology of the Stem of *Lycopodium* (Jones), 15–35.
Myeloxylon, *Brongn.*, mentioned, 61, 62.
Landriottii, *Ren.*, mentioned, 47, 59, 60.
radiatum, *Ren.*, mentioned, 60.
sp., mentioned, 45, 48, 58, 64.
Nandina, *Thunb.*, fl.-whorls, 157.
Nardus, *Linn.*, leaf-anat., 74.
Nastus borbonicus, *J. F. Gmel.*, leaf-anat., 83.
Neomeris annulata, *Dickie*, 169.
Kelleri, Cramer, 169.
Nephrodium cucullatum, Baker, 413.
elatum, *Desv.*, var. *mauritianum*, Baker, 413.
Hornei, Baker, 414.
molle, Baker, 413.
pleiotomum, Baker, 414.
tomentosum, Baker, 412.
Wardii, Baker, 413.
Nephrolepis biserrata, *Schott*, 415, 410.
cordifolia, *Presl*, 415, 410.
exaltata var. *biserrata*, Baker, 415.
tuberosa, Presl, 415.
Newfoundland, *Psygmophyllum majus*, sp., nov., from (Arber), 391–407.
Nœggerathia, *Sternb.*, 110, 118; mentioned, 121, 124, 397.
ctenoides, *Goepp.*, 402.
cuneifolia, *Kutorga*, 401.
expansa, *Brongn.*, 401.
flabellata, Brongn., 394.
flabellata, Carpentier, 403.
flabellata, Geinitz, 402.
flabellata, Lindl. & Hutt., 394.
foliosa, *Sternb.*, 118; mentioned, 397, 405.
obtusa, Lesq., 398.
vogesiaca, Bronn, 119, 120.
Nœggerathiopsis, *Feistm.*, 118, 125.
Hislopi, *Zeill.*, 118.
Nœggerathiopsis, Zeill., 112.
Nototriche, *Turcz.*, Revision of the Genus (Hill), 201–266; calyx, 205; clavis, 214–217; corolla, 205; distribution, 207; evolution, 213; fruits, 206; leaves, 203; root and stem, 201; stamens, 206; stipules, 203; tomentum, 204.
acuminata, *A. W. Hill* *, 258, 208, 209, 211, 217; mentioned, 250, 251, 259.
alternata, *A. W. Hill* *, 241, 209, 210, 216; mentioned, 236, 243.
anthemidifolia, *A. W. Hill* *, 254, 203, 204, 207, 209, 217; mentioned, 250, 251, 256, 258.
Nototriche aretioides, *A. W. Hill*, 231, 203–205, 208, 215; mentioned, 230, 235.
argentea, *A. W. Hill*, 259, 208, 217; mentioned, 250, 251, 258.
argyllioides, *A. W. Hill* *, 245, 204, 207, 209, 210, 212 ftnote, 216; mentioned, 223, 225, 240, 243, 244, 246, 247.
aristata, *A. W. Hill* *, 255, 208, 211, 217; mentioned, 250, 251, 253, 256.
artemisioides, *A. W. Hill*, 228, 204, 208, 211, 215; mentioned, 220, 235.
auricoma, *A. W. Hill* *, 220, 209, 215; mentioned, 219, 221, 227.
Azorella, *A. W. Hill*, 219, 202, 206, 208, 211, 214; mentioned, 227, 241.
borussica, *A. W. Hill* *, 236, 209, 210, 216.
Castelnæana, *A. W. Hill* *, 257, 208, 217; ment., 250, 251.
Cavanillesii (*A. Gray*), *A. W. Hill* * (nomen), 208.
cheilanthifolia, Turcz., 254.
cinerea, *A. W. Hill* *, 257, 209, 217; mentioned, 244, 250, 251, 254.
clandestina, *A. W. Hill* *, 218, 202, 204, 209, 214; mentioned, 221, 227.
coccinea, *A. W. Hill*, 219, 206, 208, 214; mentioned, 227, 235.
compacta, *A. W. Hill* *, 221, 202, 209, 211, 215; mentioned, 219, 227.
condensata, *A. W. Hill* *, 224, 206, 208, 213 ftnote, 215; mentioned, 227, 235.
congesta, *A. W. Hill*, 221, 206, 208, 215; mentioned, 219, 241.
discolor, Turcz., 254.
dissecta, *A. W. Hill* *, 238, 208, 216; mentioned, 236.
epileuca, *A. W. Hill*, 252, 206, 208, 213 ftnote, 217; mentioned, 235, 250, 251.
famatinensis, *A. W. Hill*, 227, 209, 215; mentioned, 226, 236.

Nototriche flabellata, *A. W. Hill* *, 222, 206, 207, 209, 213 ftnote, 215, 216; mentioned, 224, 227, 230, 244, 247.
Friesii, *A. W. Hill* *, 226, 209, 210, 215; mentioned, 236.
glauca, *A. W. Hill*, 257, 209, 217; mentioned, 244, 250, 251.
Hartwegii, *A. W. Hill* *, 221, 206, 208, 213 ftnote, 215, 235; mentioned, 227, 233.
Hieronymi, *A. W. Hill*, 219, 209, 214; mentioned, 221, 227, 244.
incana, Turcz., 223, 247.
Jamesonii, *A. W. Hill* *, 228, 206, 208, 209, 213 ftnote, 215, 235; mentioned, 214 ftnote, 233, 234.
lanata, *A. W. Hill* *, 229, 208–210, 215; mentioned, 244.
Lobbii, *A. W. Hill* *, 228, 202, 206, 208, 213 ftnote, 215, 216; mentioned, 235.
longirostris, *A. W. Hill* *, 252, 208, 209, 211, 217; mentioned, 251, 255, 256.
longissima, *A. W. Hill*, 257, 208, 217; mentioned, 251.
Lorentzii, *A. W. Hill*, 248, 206, 209, 213 ftnote, 216; mentioned, 214 ftnote, 223, 243, 244, 247.
Macleanii, *A. W. Hill* *, 230, 206, 208, 213 ftnote, 215; mentioned, 235.
Mandoniana, *A. W. Hill* *, 253, 207-209, 211, 217; mentioned, 250, 251, 255, 258.
Matthewsii, *A. W. Hill* *, 248, 206, 208, 213 ftnote, 217, 250; mentioned, 235, 251, 252.
magalorrhiza, *A. W. Hill* *, nomen, 209.
Meyeni, *E. Ulbrich*, 239, 209, 210, 216; mentioned, 229, 236, 237, 240, 242.
Niederleinii, *A. W. Hill*, 246, 209, 216; mentioned, 244, 247.
nigrescens, *A. W. Hill*, 223, 208, 215; mentioned, 227, 235.
obcuneata, *A. W. Hill* *, 225, 209, 215; mentioned, 219, 226, 227, 242.
Nototriche obtusa, *A. W. Hill*, 220, 208, 214; mentioned, 227, 228, 235.
Orbignyana, *A. W. Hill* *, 237, 207, 209, 210, 212 ftnote, 213 ftnote, 216; mentioned, 236, 238, 240, 243.
parviflora, *A. W. Hill* *, 238, 209, 216; mentioned, 236, 237, 240.
Pearcei, *A. W. Hill* *, 255, 208, 213 ftnote, 217; mentioned, 251, 257.
pedatiloba, *A. W. Hill* *, 240, 204, 209, 210, 212 ftnote; mentioned, 236.
pedatilobata, sphalm., 215, 216, =præc.
pedicularifolia, *A. W. Hill* *, 246, 206, 207, 209, 210, 212 ftnote, 213 ftnote, 216, 217; mentioned, 214 ftnote, 223, 229, 230, 243, 244, 248, 251, 257.
Philippii, *A. W. Hill* *, 245, 209, 216; mentioned, 243, 244, 246.
phyllanthos, *A. W. Hill* *, 232, 206, 208, 209, 211, 213 ftnote, 216, 234; mentioned, 214 ftnote, 222, 228, 235.
—— (forma), 233.
pichinchensis, *A. W. Hill* *, 231, 202, 206, 208, 211, 213 ftnote, 216; mentioned, 228, 233, 235, 249, 252, 260.
—— var. angusta, *A. W. Hill* *, 231.
pseudoglabra, *A. W. Hill*, 256, 209, 217; mentioned, 251, 255.
pulvilla, *A. W. Hill*, 226, 209, 215; mentioned, 227.
purpurascens, *A. W. Hill* *, 249, 209, 211, 217; mentioned, 254, 256.
pusilla, *A. W. Hill*, 218, 202, 208, 214.
pygmæa, *A. W. Hill* *, 218, 209, 214.
rugosa, *A. W. Hill* *, 245, 209, 216; mentioned, 243, 244, 246.
sajamensis, *A. W. Hill* *, 243, 203, 204, 207, 209, 210, 216; mentioned, 215, 226, 227, 236, 238, 240, 242.
Nototriche saltensis, *A. W. Hill*, 256, 209, 217; mentioned, 251, 255.
sericea, *A. W. Hill* *, 258, 205, 208, 210, 212 ftnote, 217; mentioned, 250, 251.
stenopetala, *A. W. Hill* *, 251, 206, 208, 213 ftnote, 217; mentioned, 235, 250, 252.
stipularis, *A. W. Hill* *, nomen, 209.
sulphurea, *A. W. Hill*, 248, 202, 206, 208, 209, 213 ftnote, 216; mentioned, 214 ftnote, 223, 243, 244, 247.
transandina, *A. W. Hill* *, 226, 209, 210, 215; mentioned, 221, 227.
turritella, *A. W. Hill* *, 241, 202, 203, 206, 207, 209, 210, 216; mentioned, 236, 239, 240, 242.
ulophylla, *A. W. Hill* *, 224, 208, 215; mentioned, 227, 246.
velutina, *A. W. Hill* *, nomen, mentioned, 255.
Nullipores, mentioned, 94, 96.
Nuphar advena, *Ait.*, fl.-whorls, 157.
luteum, *Sibth. & Sm.*, fl.-whorls, 157.
Nyctaginaceæ, mentioned, 268.
Nymphæaceæ, mentioned, 153, 157.
Nyssa, *Gronov.*, aff. to Davidia, *Baill.*, 319; infl., 312; ovary, 320; ovule, 321; mentioned, 303, 304.
sylvatica, *Marsh.*, 312.
uniflora, *Wangenh.*, 312.
Nysseæ, aff. to Davidia, *Baill.*, 322.
Nyssoideæ, mentioned, 304.

Oaks, mentioned, 87.
Ochlandra, *Thw.*, leaf-anat., 70, 71, 83, 86; seed, 87; stam., 87.
Beddomei, *Gamble*, 71, 81, 83.
Rheedii, *Benth.*, 70, 83, 86.
sp., 73.
stridula, *Thw.*, 86.
travancorica, *Benth.*, 87.
Ochropteris, *J. Sm.*, mentioned, 411.
pallens, *J. Sm.*, mentioned, 419.
Odontosoria chinensis, *J. Sm.*, 415, 410.
Oleandra articulata, *Presl*, 414, 410.

Olyra, *Linn.*, leaf-anat., 74, 87.
floribunda, *Raddi*, 87.
latifolia, *Linn.*, 87.
Ophioglossaceæ of the Seychelles, 424; mentioned, 373, 376, 385.
Ophioglossum, *Linn.*, mentioned, 373.
palmatum, *Linn.*, 424, 410.
pendulum, *Linn.*, 424, 410.
vulgatum, *Linn.*, mentioned, 382.
Origin of di-trimerous whorls (Henslow), 153–162.
Orthopterygium, *Hemsl.*, anat., 150, 129, 135–142.
Huaucui, *Hemsl.*, 151, 133, 134, 137, 138, 143, 144, 148.
Oryza, *Linn.*, leaf-anat., 73.
Oryzeæ, leaf-anat., 73, 74.
Oryzopsis, *Michx.*, leaf-anat., 74.
Osmundaceæ, mentioned, 386.
Otozamites, *F. Braun*, mentioned, 110, 123.
Ox-eye Daisy, fl.-whorls, 161, 162.
Oxytenanthera, *Munro*, leaf-anat., 83; stam., 87.
albo-ciliata, *Munro*, 83.

Padina Commersonii, *Bory*, 185.
distromatica, *Hauck*, 185.
Palæophyllales, proposed new group (Arber), 405.
Palæozamia, Phillips, 111.
Palæozoic fern, *Botrychioxylon paradoxum*, sp. nov. (Scott), 373–389.
Palaquium, *Blanco*, seedl., 197.
petiolare, *Engl.*, 197, 189, 194.
sp., 197, 189, 195.
Paniceæ, leaf-anat., 73–75.
Panicum, *Linn.*, leaf-anat., 73, 74, 80.
turgidum, *Forsk.*, 80.
Pappophorum, *Schreb.*, leaf-anat., 74.
Paris, *Linn.*, fl.-whorls, 159.
Parkeriaceæ of the Seychelles, 423.
Payena Leerii, *Kurz*, seedl., 197, 190, 194, 196, 198; mentioned, 195.
Pearson, H. H. W., communication by (Sykes), 327.
Pellæa *Barklyæ*, Baker, 419.
Doniana, *Hook.*, 418, 410.
hastata, Link, 418.
viridis, *Prantl*, 418, 410.
Pennisetum, *Rich.*, leaf-anat., 73, 74, 80.
Pennisetum dichotomum, *Del.*, 80.
Peperomia, *Ruiz & Pav.*, ovule, 322.
Peplis, *Linn.*, fl.-whorls, 158.
Percy Sladen Memorial Expedition, 1908–1909, Report No. 2, 327–354; Expedition in H.M.S. 'Sealark,' Lithothamnia collected (Foslie), 93–108, marine algæ and phanerogams collected (A. & E. S. Gepp), 163–188.
Permo-Carboniferous flora, mentioned, 110.
Phæophyceæ of the Ind. Ocean, 182–186.
Phalarideæ, leaf-anat., 73–75.
Phalaris, *Linn.*, leaf-anat., 73.
Phareæ, *Stapf*, 74, 87.
Pharus, *P. Br.*, leaf-anat., 74, 88.
latifolius, *Linn.*, 88.
scaber, H. B. K., 88.
Phleum, *Linn.*, leaf-anat., 74.
Phœnicopsis elongatus, *Morris*, 118.
Phragmites, *Trin.*, leaf-anat., 74.
Phyllostachys, *Sieb. & Zucc.*, leaf-anat., 70–84; stam., 87.
bambusoides, *Sieb. & Zucc.*, 70, 77, 80, 82, 84.
mitis, *Rivière*, 72.
spp., 81.
Phytolacca, *Tourn.*, internodes, 295–302.
decandra, *Linn.*, 297, 302.
esculenta, *Van Houtte*, 295, 296, 302; mentioned, 297, 298.
polyandra, *Batalin*, 298, 302.
Phytolaccaceæ, longitudinal symmetry, 294; mentioned, 267, 268.
Pineapples, fl.-whorls, 159.
Pinus, *Linn.*, sieve-tubes, mentioned, 31.
contorta, *Dougl.*, mentioned, 345 ftnote.
spp., mentioned, 87.
Piptatherum, *Beauv.*, leaf-anat., 74.
Plagiozamites, *Zeill. & Ren.*, 110.
Platycerium *alcicorne*, Baker, 423.
bifurcatum, *C. Chr.*, 423, 410.
Platyphyllum Brownii, Dawson, 398.
Pleuropogon, *Holm*, leaf-anat., 74, 80.
Pleurothallis, *R. Br.*, compared with Lepanthes, *Sw.*, 2.
Poa, *Linn.*, leaf-anat., 74.
Podocarpus, *Pers.*, transition, 349; mentioned, 345.
Urbanii, *Pilg.*, mentioned, 2.
Podozamites, *Bronn*, 118; mentioned, 110, 121.
distans, *Presl*, var. longifolia, *Schenk*, 117.
Polybotrya tenuifolia, Kuhn, 418.
Polygonum, *Linn.*, fl.-whorls, 153, 158.
Hydropiper, *Linn.*, 158.
Persicaria, *Linn.*, 158.
Polypodiaceæ of the Seychelles and the Aldabras, 412–423.
Polypodium *adnascens*, Bory, 421.
albobrunneum, *Baker*, 421, 410.
asplenifolium var. *minor*, Metten., 421.
cultratum, Baker, 421.
cultratum, *Willd.*, 421, 410.
—— var. elasticum, *Bory*, 421.
elasticum, Bory, 421.
irioides, Lam., 421.
Pervillei, *Metten.*, 420, 410.
phymatodes, *Linn.*, 421, 410.
punctatum, *Sw.*, 421, 410.
sechellarum (pars), Baker, 421.
serrulatum, *Metten.*, 421, 410.
spp., mentioned, 2.
spissum, Bory, 421.
Polypogon, *Desf.*, leaf-anat., 74.
Polystichum adiantiforme, *J. Sm.*, 414, 410.
Polytrema, *Fér.*, sp., mentioned, 94.
Poroxylon, *Bertrand & Ren.*, mentioned, 45.
Portulaccaceæ, longitudinal symmetry, 299; mentioned, 267, 268.
Posidonia, *Kon.*, mentioned, 356.
Potamogeton, *Linn.*, fl.-whorls, 159.
Potamogetonaceæ of the Ind. Ocean, 186.
Primofilices, mentioned, 405.
Primula officinalis, *Jacq.*, fl.-whorls, 161.
sinensis, *Sabine*, 204.
Proangiospermeæ, mentioned, 116, 124.
Prunus Laurocerasus, *Linn.*, fl.-whorls, 158, 161.
occidentalis, *Sw.*, mentioned, 2.
serrulata, *Lindl.*, infl., 312.
Psamma, *Beauv.*, leaf-anat., 74.

Pseudostachyum polymorphum, *Munro*, leaf-anat., 81.
Psygmophyllum, *Schimp.*, its revision, 397–403; sp. nov., 392.
angustilobum, Schenk, 402.
Brownii, *Arber* *, 398; mentioned, 394, 399, 400, 404.
cuneifolium, Schimp., 397, 400.
Delvali, Camb. & Renier, 403.
expansum, Schimp., 397, 400, 402.
flabellatum, *Arber* *, 394, 398, 400, 404; mentioned, 392, 399, 401, 402.
flabellatum, Schimp., 394.
Haydeni, Sew., 403 ftnote.
Hollandi, Sew., 403.
Kidstoni, *Sew.*, 400, 404.
majus, *Arber* *, 392, 398; mentioned, 391, 399.
obtusa, *Arber* *, 398, 404.
sp., 392.
Williamsoni, *Nath.*, 399; mentioned, 392, 399, 404.
Pteridella viridis, Metten., 418.
Pteris atrovirens, *Willd.*, 419, 410.
Barkleyæ = seq.
Barklyæ, *Metten.*, 419, 410.
biaurita, *Linn.*, 419, 410.
—— subsp. quadriaurita, *Retz.*, 419, 410.
dichotoma, Baker, 419.
—— var. *elongata*, Metten., 419.
incisa, Baker, 419.
marginata, Bory, 419.
nemoralis, Willd., 419.
quadriaurita, *Retz.*, *vide* biaurita.
tripartita, *Sw.*, 419, 410.
Pterophyllum, *Brongn.*, and Zamites, *Brongn.*, Triassic Species of the Genera (Arber), 109–127.
Bronnii, Schenk, 117, 120, 124.
giganteum, Schenk, 113, 116.
Jægeri, *Brongn.*, mentioned, 120.
longifolium, *Brongn.*, 123; mentioned, 120.
spp., mentioned, 125.
Pychnophyllum, *Remy*, mentioned, 283.

Quercus, *Linn.*, mentioned, 42, 190.
spp., mentioned, 87, 303.

Rachiopteris corrugata, Will., 383, 384.
Williamsoni, Sew., pet., 60; mentioned, 45.
Rœlfsia ceylanica, Harv., 164, 184.
Ranunculaceæ, mentioned, 153.
Ranunculus Ficaria, *Linn.*, fl.-whorls, 162.
Rendle, A. B., *see* Fawcett and Rendle.
Revision of the genus *Nototriche*, Turcz., 201–266; of the genus *Psygmophyllum*, Schimp., 397–403.
Rhacophyllum truncatum, *Lesq.*, mentioned, 398.
Rhætic flora of Theta, mentioned, 119.
Rhamneæ, mentioned, 132.
Rheum, *Linn.*, fl.-whorls, 158.
Rhipidopsis, *Schmalh.*, mentioned, 400–405.
Rhipidosiphon javensis, Mont., 174, 175.
Rhus simulata, *F. E. Fritsch**, nomen, leaf-anat., 138.
Robinia monophylla, *Hort.*, mentioned, 204 ftnote.
sp., mentioned, 381.
Rosaceæ, mentioned, 321.
Rubiaceæ, ovules, 322.
Rumex, *Linn.*, fl.-whorls, 153, 156, 158, 161.

Saccharum, *Linn.*, leaf-anat., 73, 74.
Salicornia, *Linn.*, sp., mentioned, 267.
Salsola Kali, *Linn.*, internodes, 281, 301; mentioned, 269.
Sambucus, *Tourn.*, fl.-whorls, 159; infl., 314; ovary, 320; ovules, 322; seed, 318.
nigra, *Linn.*, 159, 314, 322.
Sanday, E., *see* Benson, M., E. Sanday and E. Berridge.
Sapotaceæ, mentioned, 189.
Sapotaceous seedlings, their anatomy (Smith), 189–200.
Sargassum duplicatum, *J. Ag.*, 182.
persicum, *Kuetz.*, 182.
subrepandum, *Ag.*, 182.
vulgare, *Kotschy*, mentioned, 182.
—— var. latifolium, *Endl. & Dies.*, mentioned, 182.
Sasa paniculata, *Makino & Shibata*, leaf-anat., 71, 76.
Saxifraga, *Tourn.*, infl., 313.
Scheffléreæ, aff. to Davidia, *Baill.*, 319.
Schizæa digitata, *Sw.*, 424, 410.
—— var. *intermedia*, Baker, 424.
Schizæaceæ of the Seychelles, 424.
Schizoloma ensifolium, *J. Sm.*, 415, 410.
Scott, D. H., on *Botrychioxylon paradoxum*, sp. nov., 373–389; on *Sutcliffia insignis*, a new type of Medulloseæ, 45–68.
'Sealark' Expedition, calcareous algæ collected, 93; marine algæ and phanerogams collected (A. & E. S. Gepp), 163–188.
Secondary wood, a Palæozoic fern with, 373–389.
Seedlings, anatomy of Sapotaceous (Smith), 189–200.
Selaginella, *Beauv.*, mentioned, 17, 20.
spp., mentioned, 63.
Selago, *Linn.*, subgen., mentioned, 32.
Sequoia, *Endl.*, mentioned, 345.
Sesleria, *Scop.*, leaf-anat., 74.
Setaria, *Beauv.*, leaf-anat., 74.
Seychelles and the Aldabras, their Ferns (Christensen), 409–425.
Shorea robusta, *Gaertn. f.*, mentioned, 87.
'Siboga' Expedition, mentioned, 166.
Sida acaulis, *Cav.* (sp. dub.), 217, 260; mentioned, 233.
anthemidifolia, Remy, 254.
borussica, Meyen, 236, 237, 239.
clandestina, Phil., 219.
compacta, Gay, 221.
megalorrhiza, *Phil.* (sp. dub.), 217, 260.
pedicularifolia, Meyen, 247.
pichinchensis, Humb. & Bonpl., 231–234.
pinnata, *Cav.* (sp. dub.), 217, 259; mentioned, 233, 249.
phyllanthos, Cav., 232, 233–235, 259.
phyllanthos, H. B. K., 232.
pygmæa, Remy, 218.
rosula, Meyen, 236.
Saxifraga, Humb. & Bonpl., 232–234.

Sigillariopsis sulcata, *D. H. Scott*, mentioned, 45.
Simaba glandulifera, *Gardn.*, mentioned, 78.
SIMARUBACEÆ, mentioned, 130.
Sladen Expedition, *see* Percy Sladen Expedition.
Smith, Winifred, anatomy of Sapotaceous seedlings, 189–200.
Solanum punctulatum, *Dun.*, mentioned, 2.
Sorghum, *Linn.*, leaf-anat., 74.
Spartina, *Schreb.*, leaf-anat., 73.
Sphenophyllum fertile, *D. H. Scott*, mentioned, 45.
  interrupte-pinnata, *Kutorga*, 401.
  tenerrimum, *Stur*, 391, 398.
Sphenozamites, *Brongn.*, 110, 123; mentioned, 125.
  Rogersianus, *Fontaine*, 122.
  tener, *Compter*, 122.
Spiræa, *Linn.*, mentioned, 315.
Spondias mangifera, *Willd.*, leaf-anat., 138.
Sporobolus, *R. Br.*, leaf-anat., 74, 80.
  spicatus, *Kunth*, 80.
Spruce, mentioned, 87.
Spruce-fir, fl.-whorls, 161.
SQUAMARIACEÆ, mentioned, 95, 96, 101.
Stangeria, *T. Moore*, mentioned, 198.
Stellaria, *Linn.*, mentioned, 283.
  media, *Cyrill.*, internodes, 285, 301.
Steloxylon Ludwigii, *Solms*, mentioned, 63.
Stenochlæna Pervillei, *Underw.*, 418, 410.
  tenuifolia, *T. Moore*, 418, 410.
Stipa, *Linn.*, leaf-anat., 74, 79.
  altaica, *Trin.*, 79.
Stratiotes, Linn. f., 355.
Strobilanthes, *Blume*, spp., mentioned, 87.
Structure and Affinities of *Davidia involucrata*, Baill. (Horne), 303–326.
Struvea delicatula, *Kuetz.*, mentioned, 168.
  Gardineri, *A. & E. S. Gepp* *, 166; mentioned, 163.
  macrophylla, *Harv.*, mentioned, 167.
  orientalis, *A. & E. S. Gepp* *, 167; mentioned, 163, 167.
Struvea pulcherrima, *G. Murr. & Boodle*, mentioned, 167.
  ramosa, *Dickie*, mentioned, 168.
Subselago, *Baker*, subgen., mentioned, 32.
Sunflower, fl.-whorls, 161.
Sutcliffia, *D. H. Scott* *, 62, 45.
  insignis, *D. H. Scott* *, 62, 45; affinities, 63–65; general structure, 47–50; histology, 55–59, 65; meristyle, 50–55, 65; occurrence, 45; petioles, 59–62, 65.
  Williamsoni, *D. H. Scott* *, 62, 63.
Sykes, M. G., Anatomy of *Welwitschia mirabilis*, Hook. f., 327–354.
Symmeria, *Benth.*, fl.-whorls, 153, 158.
Symphoricarpus, *Juss.*, infl., 304; ovary, 320; ovules, 321, 322.

Teinostachyum Wightii, *Bedd.*, leaf-anat., 77.
TEREBINTHACEÆ, mentioned, 130.
Thinouia, *Planch. & Triana*, mentioned, 49 ftnote.
Tilia, *Linn.*, mentioned, 306.
Tradescantia, *Rupp.*, fl.-whorls, 161.
Tragus, *Hall.*, leaf-anat., 73.
Triassic Species of *Zamites*, Brongn., and *Pterophyllum*, Brongn. (Arber), 109–127.
Trichomanes cupressoides, *Desv.*, 411, 410.
  cuspidatum, Kuhn, 411.
  cuspidatum, *Willd.*, 411.
  erosum, *Willd.*, 411, 410.
  obscurum, *Blume*, mentioned, 412.
  —— var. *pectinata*, Metten., 411.
  rigidum, Baker, 411.
  spp., mentioned, 2.
Trichomanites filicula, Dawson, 398.
Trichopitys, *Sap.*, mentioned, 404, 405.
Triodia, *R. Br.*, leaf-anat., 74.
Tripsacum, *Linn.*, leaf-anat., 74.
Trisetum, *Pers.*, leaf-anat., 74.
Triticum, *Linn.*, leaf-anat., 74.
Tulipa, *Linn.*, fl.-whorls, 156, 161.
Turbinaria, *Lamour.*, mentioned, 164.
  condensata, *Sond.*, 184.
  conoides, *Kuetz.*, 182.
  —— var. evesiculosa, *E. S. Bart.*, 182.
Turbinaria decurrens, *Bory*, 183.
  dentata, E. S. Bart., 184.
  Murrayana, *E. S. Bart.*, 185; mentioned, 164.
  ornata, *J. Ag.*, 183; mentioned, 164.
Tydemania, *Web. van Bosse*, 174.
  expeditionis, *Web. van Bosse*, 174; mentioned, 163.

Udotea *amadelpha*, Mont., 178.
  argentea, *Zanard.*, mentioned, 164, 176.
  —— f. typica, *A. & E. S. Gepp* *, 176.
  conglutinata, *Lamour.*, 175; mentioned, 177.
  —— f. infundibuliformis, *A. & E. S. Gepp* *, mentioned, 178.
  cyathiformis, Decne., 178.
  glaucescens, *Harv.*, 175; mentioned, 163.
  Infundibulum, J. Ag., 178.
  javensis, *Gepp*, 174, 175.
  Palmetta, *Decne.*, 175; mentioned, 163, 164.
Ulva fasciata, *Del.*, 164.
ULVACEÆ of the Indian Ocean, 164.
UMBELLIFERÆ, mentioned, 132, 315.
Uniola, *Linn.*, leaf-anat., 74.
UNISEXUALES, mentioned, 130 ftnote.

Valonia confervoides, *Harv.*, 169.
  fastigiata, *Harv.*, 169.
VALONIACEÆ of the Ind. Ocean, 168.
Vancouveria, *Morr. & Decne.*, fl.-whorls, 157.
VERTICILLATÆ, proposed disuse of the term, 43.
Viburnum Lantana, *Linn.*, infl., 312; ovary, 320; ovules, 322.
  stellulatum, *Wall.*, infl., 312.
Vittaria *elongata*, *Baker*, 420.
  elongata, *Sw.*, 410.
  —— var. ensiformis, *C. Chr.*, 420.
  ensiformis, Sw., 420.
  isoetifolia, *Bory*, 420, 410.
  lineata, Baker, 420.
  plantaginea, Bory, 420.
  scolopendrina, *Thw.*, 420, 410.
Voltzia, *Brongn.*, sp., mentioned, 115 ftnote.

Welwitschia mirabilis, *Hook. f.*, its Anatomy, in the Seedling and Adult States (Sykes), 327–354; cotyledonary buds, 339; develop. of outward form, 328–333; ridges and inflorescences, 337–339; root system, 334–337; stem, 347–348; transition, 340–346, 349; xylem, 346.
Whorls, di-trimerous, among the Flowers of Dicotyledons (Henslow), 153–162.
Williamsonia gigas, *Lindl. & Hutt.*, 116; mentioned, 112 ftnote.

Yuccites (pars), Sap., 111.
Yuccites (pars), Schimp., 111.
Yuccites, *Schimp. & Moug.*, 111; mentioned, 118, 124.
  angustior, *Sap.*, 116.
  burgundiacus, *Sap.*, 116.
Yuccites *dubius*, Schimp. & Moug., 113.
  Schimperianus, *Zigno*, 116.
  spp., mentioned, 115.
  vogesiacus, Schimp., 113.
  vogesiacus, Schimp. & Moug., 113, 115, 121.
Yuccites (pars), Zigno, 111.

Zamia, *Linn.*, mentioned, 112, 125.
  furfuracea, *Ait.*, mentioned, 125.
  sp., mentioned, 112.
  Washingtoniana, *L. F. Ward*, 119.
Zamites, *Brongn.*, and Pterophyllum, *Brongn.*, Triassic Species of the Genera (Arber), 109–127.
  africana, *Tate*, mentioned, 119.
  buchianus, *Ett.*, 116; mentioned, 113.
  Feneonis, *Brongn.*, 116; mentioned, 112.
  gigas, Lindl. & Hutt., 112, 116.
Zamites grandis, *Arber* *, 113, 115; mentioned, 121–123.
  megaphyllus, *Phillips*, 117; mentioned, 119.
  Milleri, *Zigno*, mentioned, 119.
  Renevieri, *Heer*, mentioned, 119
  vogesiacus, Arber, 113.
  vogesiacus, *Schimp. & Moug.*, mentioned, 115.
Zea, *Linn.*, leaf-anat., 74.
Zonaria *Isselii*, Piccone & Grunow, 184.
  variegata, *Mart.*, 184; mentioned, 164.
Zostera, *Linn.*, mentioned, 360.
  nana, *Roth*, 186.
Zoysieæ, leaf-anat., 73, 75.
Zygopterideæ, mentioned, 373 ftnote, 376, 385.
Zygopteris, *Corda*, mentioned, 373, 380.
  corrugata, Will., mentioned, 373.

PRINTED BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

LINNEAN SOCIETY OF LONDON

MEMORANDA CONCERNING TRANSACTIONS.

The First Series of the Transactions, containing both Botanical and Zoological contributions, has been completed in 30 Vols., and a few entire sets are still for sale. Only certain single volumes, or parts to complete sets, may be obtained at the original prices. The price of the Index to Vols. 1–25 is 8*s.* to the public, and 6*s.* to Fellows; to Vols. 26–30, 4*s.* to the public, and 3*s.* to Fellows.

The Second Series of the Transactions is divided into Zoological and Botanical sections. The prices of the Botanical parts of these which have been published are as undermentioned. (For the Zoological parts see Zoological wrapper.)

Second Series.—Botany.

Volume.	When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
I. Parts I.–IX. (complete).	1875–80.	8	1	0	6	1	0
II. Parts I.–XVI. (complete).	1881–88.	6	16	10	5	2	9
III. Part I.	1888.	3	12	0	2	14	0
Part II.	1891.	0	5	0	0	3	9
Part III.	1891.	0	7	0	0	5	0
Part IV.	1891.	0	6	0	0	4	6
Part V.	1891.	0	6	0	0	4	6
Part VI.	1891.	0	3	6	0	2	8
Part VII.	1892.	0	6	0	0	4	6
Part VIII.	1893.	0	6	0	0	4	6
Part IX.	1893	1	8	0	1	1	0
Part X.	1894.	0	10	0	0	7	6
Part XI.	1894.	0	3	4	0	2	6
IV. Part I.	1894.	1	0	0	0	15	0
Part II.	1894.	2	0	0	1	10	0
Part III.	1895.	2	10	0	1	17	0
Part IV.	1896.	0	3	4	0	2	6
V. Part I.	1895.	0	9	0	0	6	9
Part II.	1896.	0	12	0	0	9	0
Part III.	1896.	0	6	0	0	4	6
Part IV.	1896.	1	0	0	0	15	0
Part V.	1896.	0	14	0	0	10	6
Part VI.	1896.	0	4	0	0	3	0
Part VII.	1897.	0	4	0	0	3	0
Part VIII.	1897.	0	6	0	0	4	6
Part IX.	1899.	0	12	0	0	9	0
Part X.	1899.	0	6	0	0	4	6
Part XI.	1899.	0	7	0	0	5	0
Part XII.	1899.	0	12	0	0	9	0
Part XIII.	1900.	0	1	6	0	1	2
Part XIV.	1900.	0	3	0	0	2	3
Part XV.	1901.	0	6	0	0	4	6

Second Series.—Botany (*continued*).

Volume.	When Published.	Price to the Public. £	s.	d.	Price to Fellows. £	s.	d.
VI. Part I.	1901.	1	10	0	1	2	6
Part II.	1901.	0	6	0	0	4	6
Part III.	1902.	0	18	0	0	13	6
Part IV.	1903.	0	8	0	0	6	0
Part V.	1903.	0	8	0	0	6	0
Part VI.	1903.	0	12	0	0	9	0
Part VII.	1904.	0	12	0	0	9	0
Part VIII.	1904.	0	12	0	0	9	0
Part IX.	1904.	0	7	0	0	5	3
Part X.	1904.	0	14	0	0	10	6
Part XI.	1905.	0	4	0	0	3	0
VII. Part I.	1904.	0	5	0	0	3	9
Part II.	1905.	0	6	0	0	4	6
Part III.	1906.	0	3	0	0	2	3
Part IV.	1906.	0	7	0	0	5	3
Part V.	1907.	0	10	0	0	7	6
Part VI.	1907.	0	4	0	0	3	0
Part VII.	1907.	0	6	0	0	4	6
Part VIII.	1908.	0	5	0	0	3	9
Part IX.	1908.	0	2	6	0	2	0
Part X.	1908.	0	7	0	0	5	3
Part XI.	1909.	0	4	0	0	3	0
Part XII.	1909.	0	12	0	0	9	0
Part XIII.	1909.	0	5	0	0	3	9
Part XIV.	1909.	0	6	0	0	4	6
Part XV.	1910.	0	6	0	0	4	6
Part XVI.	1912.	0	3	0	0	2	3
Part XVII.	1912.	0	8	0	0	6	0
Part XVIII.	1912.	0	5	0	0	3	9
Part XIX.	1912.	0	3	0	0	2	3
Part XX.	Index.	0	3	0	0	2	3
VIII. Part I.	1913.	1	0	0	0	15	0